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ROAD RESEARCH IN GREAT BRITAIN

THE Minister of Transport, Mr. A. Lennox-Boyd, recently stated in the House of Commons that to delay an extended programme of major road improvements would cause serious damage to the economy of Great Britain. Thus, officially admitting the economic justification of an adequate road system for Britain, the Minister simultaneously announced that the total Exchequer expenditure on the schemes to be authorized in the next three financial years would not exceed £50 million, mainly to be spent on ameliorative schemes. Many of these schemes have been pressed upon successive Governments since before the Second World War. No major reconstruction schemes to forestall serious damage to our economy are to be undertaken, and Sir Gurney Braithwaite's proposal in the debate on February 15 for a thirty-year loan of £500 million for roads, in addition to existing financial allocations, to permit the planning of road improvements and developments and the allocation of materials and labour on a firm basis, was rejected.

Much of that debate was concerned with questions of road safety and the prevention of accidents, which have been a major factor in focusing public attention on the problems of roads and in inducing what is really a new departure in Government policy. If, however, the Government had accepted Sir Gurney Braithwaite's suggestion, there would still have been some difficulty in determining priorities as between the many schemes and proposals which have been advanced to relieve congestion on the roads. Dissatisfaction over the choice actually made and discussion of the rival claims tend rather to divert attention from the fact that the basic problem is not yet being tackled.

The problem is to be seen in its true perspective, not in the light of the debates in Parliament but in the light of the comments on road research in the latest report of the Department of Scientific and Industrial Research and in that of the Select Committee on Estimates for the Session 1952–53 dealing with roads to which the Advisory Council directs attention. Even there, however, it is more by implication than by direct comment that the effect of the cuts in the work of the Road Research Laboratory and the curtailment of the Department's post-war plans for the Laboratory necessitated by the ill-judged reduction in the Department's vote is evident. The Road Research Laboratory is only one of many branches of the Department's work which have to be considered in apportioning the resources available, and though Sir Ben Lockspeiser claimed in evidence before the Select Committee that its researches had saved the country several million pounds a year, that is a reason not so much for special grants to road research as for a wise and generous policy towards the Department as a whole.

Leaving aside for the moment that aspect of road research which is concerned with road safety—though Lord Lucas last July put the loss to the

nation's economy through road accidents alone at £146 million annually—the work of the Road Research Laboratory aims at providing the fundamental knowledge of the properties of materials and of the methods of road construction which would permit those materials to be used more efficiently, with less labour and with less maintenance. Sir Ben Lockspeiser admitted in his evidence that, so far as the design of a road in relation to the type of soil and the amount of traffic it is to carry is concerned, our knowledge is in its infancy. The Select Committee, in fact, was satisfied that the one way in which any significant reduction in expenditure on the roads could be made, and the one way in which, in the present economic difficulties, anything could be done substantially to improve the condition of the roads, is by the use of new methods and machinery, such as it is the purpose of the Road Research Laboratory to elaborate.

The Select Committee therefore recommended that immediate consideration be given by the Ministry of Transport and by the Treasury, in conjunction with the Department of Scientific and Industrial Research, to the expansion of the work of the Road Research Laboratory, the necessary cost being met by a corresponding reduction in the Treasury contribution to the Road Fund. It also expressed the opinion that the full possibilities of the work of the Laboratory are not generally realized. Although it is not easy to see how any reduction in expenditure on highways can be effected otherwise than by the use of up-to-date methods and equipment, to the development of which the work of the Laboratory directly contributes, the Ministry of Transport was unprepared to commit itself as to the desirability of expanding that work. Accordingly, the Select Committee requested the Department to prepare a supplementary memorandum on road research and its application, in which reasons are given for believing that additional expenditure estimated at an initial £240,000 and an annual increase of £155,000 (compared with the total expenditure of £312,728 gross for 1952–53) would offer economies which could run into millions of pounds a year.

For the most part, the measures proposed in this memorandum were those included in the Department's post-war plans for the Laboratory, now expected to be completed by 1959. The programme includes proposals for further research on road-making machinery, for example, on machines for moving and excavating soil; for mixing soil and cement for soil stabilization, particularly for mix-in-place work; for spreading and compacting concrete; for removing snow and ice from roads and runways; driers for use in connexion with tar macadam and asphalt plants; and plant for producing crushed stones in the sizes required by the industry. Besides this, the Laboratory's facilities for testing existing machines and prototypes could usefully be extended.

No estimate is attempted of the probable monetary savings that would result from this work, which would involve additional scientific, technical and industrial staff of forty to fifty and an expenditure of £40,000 per annum; apart from the contribution to the export market and assistance given to other industries, the return is to be found in increased output and improved quality of materials and workmanship. Nor is any estimate attempted of the probable return from the further expenditure of about £30,000, with an increase of thirty in the non-industrial staff, needed to redress the balance of fundamental research on materials and methods of construction, particularly on the basic factors determining the cost and life of different forms of road-surfacing and on asphalt made from the new crude oils from the Middle East. Unless steady progress in this fundamental research is maintained, however, the ability of the Laboratory to deal effectively with questions of technical application is bound to suffer and its contribution to road-making economy will be reduced.

The memorandum stresses particularly the need for sites for experimental roads, which are now required in the Laboratory's work on design and construction, to permit the full-scale demonstration of the possibilities of the new and potentially more economical forms of construction. The initial expenditure of £240,000 is required for this purpose on a site at Alconbury Hill, Huntingdonshire, where it would provide the opportunity for essential research and also some miles of modern trunk road at a point where it is badly needed. A small road experiment in Yorkshire in 1949 demonstrated that savings of at least £20,000–£30,000 per mile could be made in that area, and even greater savings are to be expected in the construction of roads over clay soils.

For research into road safety and traffic, the memorandum proposes an increase of twenty-five in non-industrial staff and an additional expenditure of £35,000, so as to permit a considerable speeding up of the investigations with the view of obtaining rapid economic returns. Such investigations include the study of the control of traffic at intersections; estimation of the economic cost of traffic delays for comparison with the cost of the road works and other measures that would relieve them; detailed study of traffic flow, and use in practice of principles already deduced from research; effect of minor road improvements, such as dealing with places where accidents frequently occur (the cost of which was estimated by Lord Lucas in a House of Lords debate last year as £150 million), improvement of lighting, etc., to establish the economic principles on which sites for improvements should be selected; study of rates of accident on different types of roads to assess the economic benefits of wider and straighter roads; design of street lighting in relation to the reflecting powers of road surfaces; combination of road surface texture and tyre tread pattern which will ensure the best combination of durability and skidding resistance in both roads and tyres; value of measures of protection for pedestrians; and (in collaboration with the Medical Research Council) investigation into the effect on drivers of various physical disabilities. Road accidents are estimated to cost the nation at least £100 million per annum (Lord Lucas quoted an estimate of £146 million) and traffic delays an

unknown but large amount which must form an important part of the 10–15 per cent of the total cost of production and distribution in Britain which is attributed to commercial road-use.

The magnitude of the net savings which would result from the reduction of accidents and traffic delays through the application of measures based on the results of research need scarcely be stressed here. The problem is, however, to secure their application. It is particularly acute in regard to the introduction of improved and cheaper methods in place of well-established practices, as Sir Ben Lockspeiser explained in his evidence. While appreciating the misgivings with which the Laboratory regards any suggestion that highway authorities should be under a direct obligation to consult the Laboratory, the Select Committee held that the work of the Laboratory is too valuable to be passed over. One of its main recommendations is that the Ministry of Transport and the Department of Scientific and Industrial Research should consult together with the view of improving the means by which results obtained by the Road Research Laboratory are made known to interested bodies.

To further the quicker application of the results of research, the memorandum already quoted proposes a demonstration staff of twenty to thirty and expenditure of about £50,000 per annum. Such a demonstration service, to show, by actual work on roads, how to use new or improved methods, offers savings put at many millions of pounds a year. Use of soil–cement construction instead of concrete for housing-estate roads, for example, is estimated to offer savings of £1·5 million out of £10 million, while a more general use of technical control in the application of bituminous surfacings offers savings estimated at £200,000 a year. Assistance given by the Laboratory to one county surveyor in Scotland enabled twenty miles of road to be re-surfaced at the same price as that for eleven miles with more orthodox materials.

It is worth noting in this connexion that a memorandum on highways expenditure submitted in evidence to the Select Committee by the County Councils Association expressed the hope that no search for economies would lead to any reduction in the expenditure on research into road techniques and materials and problems of traffic flow and accidents undertaken by the Road Research Board. The value of such research is, the Association thinks, out of all proportion to the relatively small cost involved—an insignificant proportion of the total expenditure on highways—estimated as more than £73 million in 1950–51. The current report of the Department of Scientific and Industrial Research indicates that the Road Research Laboratory is already paying particular attention to securing the practical application of the results of its work.

Meanwhile, the Advisory Council intends to respond to the best of its ability to the Select Committee's desire to see the Laboratory's work expanded, though it is obvious that expenditure contemplated in the memorandum already quoted is almost as large as the total increase in the Department's estimates for 1954–55 when allowance is made for the provision for European nuclear research. Even then, however, expenditure on road research would be well below half a million pounds a year, and this figure should be set against the £90 million which, according to the Earl of Selkirk's reply for the Government in the House of Lords debate on March 3, is being spent on roads this year—a figure which will rise to £100 million in coming years. The Earl of Selkirk claimed that during the past thirty years we have never, except in the war years, spent less than £50 million a year on the roads; but it should also be remembered that, as Lord Brabazon pointed out, while expenditure on road transport was about £1,200 million in 1950 and £1,400 million in 1951 and road taxation yields £293 million (£67 million from licences and £226 million from fuel taxes), we are only spending £4·5 million on improvements in roads (£1·5 million of which is to remove 'black spots' and £1·5 million on new roads (including roads on new housing estates)) compared with £10·5 million and £3·25 million, respectively, before the Second World War.

This reduction Lord Brabazon estimated as, in effect, one of about 90 per cent on pre-war expenditure, and the debate also brought from Lord Latham a strong plea for a series of comprehensive programmes of road construction and improvement, properly phased for execution during the next twenty or thirty years. Lord Waleran emphatically challenged the suggestion that there is any shortage of civil engineers, technicians or surveyors to prevent the initiation of such a programme, and quoted Sir George Burt's statement that civil engineering was never before so well equipped and prepared for carrying out road reconstruction work on a large scale.

The Earl of Selkirk did not suggest in his reply that there is any present shortage of engineers or surveyors, but said that a shortage might develop if reconstruction schemes were to be launched on too ambitious a scale. What seems much more important is whether, as Lord Lucas questioned, the money is being spent to the best advantage, and this reinforces the Select Committee's recommendation for more attention to the dissemination of existing knowledge and to securing the early utilization of the results of road research. The examples of the work already being carried out by the Road Research Laboratory which are given in the recent report of the Department of Scientific and Industrial Research well illustrate the value of the Laboratory's work; but they need to be more widely known.

The survey of accidents involving motor-assisted cycles has, for example, indicated that in many such accidents a motor-car collided with the cycle when one or other turned right, and because the driver of the car greatly under-estimated the speed of the cycle: some clearer indication appears to be needed that a cycle has power assistance. Other important work has been carried out on braking and on dazzle from head-lights, and the Laboratory has developed an 'automatic delay computor' which calculates the delay at fixed-time traffic signals for any settings of

the 'green' times and for any traffic fed into it. Some reference has already been made to the cement-stabilized soil process for road foundations. Great interest is also being taken in the soil-boring machine devised by the Laboratory to investigate the nature and condition of the subsoils. Another main investigation is concerned with the construction of roads on peats and morainic deposits, and another with the modifications required to the techniques of surface dressing and of designing bituminous surfacings developed for English conditions to make them best suited to the climatic conditions of Scotland; attention is also being concentrated on improving the accuracy of operation of asphalt and coated macadam plants, so that materials can be manufactured accurately to specification.

Examples of this type of work being carried out by the Road Research Laboratory are particularly worth noting, because while their value in terms of human life and happiness as well as of the efficiency of transport should be obvious, ill-informed criticism of the work of the Laboratory still persists. The recent report from the Department of Scientific and Industrial Research indicates that there is something which the scientist as such could do to secure a better appreciation of the work of the Laboratory and firmer support for its activities. On the wider issue of road reconstruction and improvement generally, it can be said that the more vigorously the work of the Laboratory is now carried out, the greater will be the possibilities of economy in materials and labour when an adequate programme of reconstruction and development is initiated. As to the timing of such a programme, and the adequacy of the measures now proposed by the Government, scientists are entitled to voice their views as citizens. Any part which they may play beyond that, as scientists, in helping to secure that the work of the Road Research Laboratory is more widely known and better understood, will assist in the task of public education which is required to make known the results of its work and to promote the co-operation and goodwill that are fundamental to their adoption.

STRUCTURE OF ORGANIC CRYSTALS AND MOLECULES

Organic Crystals and Molecules

Theory of X-Ray Structure Analysis with Applications to Organic Chemistry. By Prof. J. Monteath Robertson. (The George Fisher Baker Non-resident Lectureship in Chemistry at Cornell University.) Pp. xi+340. (Ithaca, N.Y.: Cornell University Press; London: Oxford University Press, 1953.) 32*s*. 6*d*. net.

BY the beginning of the present century the subject of organic chemistry was already an advanced and exact science. The stereochemical formulæ of many thousands of molecules were known and it may have seemed that new methods of determining the structures of organic molecules were almost redundant. The success of the first analyses of crystal structures by means of X-ray diffraction was so striking, however, that it was not long before it was realized that this method might give details of exact interatomic distances, valency angles and intermolecular forces which would be outside the range of purely chemical investigations. Moreover, the later developments of the X-ray diffraction method, involving Fourier synthesis of all the intensity observations, were able to give the general electron distribution in the molecule and so provide data for comparison with quantum mechanical calculations.

Each structural determination, however, has so far been a major piece of research and most have involved new tactics of some kind. Some research workers have concentrated on the relatively simpler groupings, hoping to work towards the complex molecules and in particular the biological compounds, by a building-up process. Others have tackled the most complex biological materials straight away, expecting by means of comparisons, by examining the effects of physical processes such as stretching or shrinkage, or those of wetting or drying, to get some insight into major architectural features. Almost all those who have worked in these two fields have themselves contributed much towards advancement of the experimental, mathematical or computational techniques. Now they are beginning to see the way by means of which some structural analyses, at least, may become matters of routine.

Prof. J. M. Robertson has himself been one of the foremost research workers in the X-ray crystallographic field. He has contributed a great deal to the development of the necessary apparatus and methods and he has a remarkable number of detailed structural investigations of simpler organic compounds to his credit, apart from those contributed by members of his school of X-ray crystal analysis in the Chemistry Department of the University of Glasgow. It was most fitting, therefore, that he should have chosen to speak on this subject when invited to give the George Fisher Baker Lectures in Chemistry at Cornell University. He has, in writing up these lectures for publication, produced a book which, within its self-imposed limits, is a model of what such a book should be. It is cheap at the price.

Beginning with the idea of a crystal as a finite body from the external point of view, but as built on an infinite repeating and symmetrical pattern internally, he shows how different X-ray diffraction methods can be applied to the determination of all the geometrical aspects of the structure. Throughout this section he gives proofs where they are needed and is careful to use the modern space-group nomenclature and diagrammatic representation, so that the work ties up with the new International Tables for X-ray Crystallography. Since he is mainly interested in the analysis of single crystals, powder and fibre methods are not described in any great detail, but their usefulness to the chemist is not overlooked.

Passing from the positions of the diffracted beams to their intensities, he shows how these may be used to give the positions of the atoms with certainty and accuracy. A valuable section is devoted to methods, some of which are still being developed and explored, of solving the crystallographer's most difficult problem, that of determining the relative phases of the diffracted waves. The question of homometric structures is also discussed. It seems probable from some recent investigations that this pitfall, of

postulated structures which do in fact give identical diffraction effects, needs more practical consideration than it has generally received so far.

Part 2 gives an account of the results of the analysis of some organic molecular structures. This section will be particularly valuable to students both of crystallography and of chemistry. Many young workers in this field are graduate physicists whose knowledge of organic chemistry is rudimentary. Prof. Robertson's treatment, which by following the historical sequence does in fact pass from the very simplest structures to those of greatest complexity, is admirably suited to lead them gently but authoritatively to an understanding of one important side of crystallographic investigation. The young chemist, on the other hand, is made to realize, with force and clarity, how valuable are crystallographic studies in supplementing information gained by way of the standard chemical methods. Now that X-ray methods have become sufficiently refined to be able to indicate the positions of hydrogen atoms, the already large body of structural information relating to hydrogen-bonded compounds is seen to be capable of much future extension.

References are given throughout the book, and there are good name and subject indexes.

K. LONSDALE

PHYSIOLOGY OF INSECTS

Insect Physiology

Edited by Kenneth D. Roeder. Pp. xiv+1,100. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 120*s*. net.

THE insects as a group are distinguished from other classes of animals not only by their abundance and diversity and by their great economic importance but also by their physiology. They have a highly complex cuticular covering, a tracheal system of respiration, a characteristic endocrine system which regulates their striking metamorphoses, a capacity for flight, with flight muscles showing rates of contraction and relaxation which may exceed 1,000 per second, and elaborate sense organs and nervous system. There is therefore some justification for presenting a separate account of their physiology.

The manner in which this subject is to be treated presents a difficult problem to the author. Is he to take for granted in the reader a knowledge of general physiology and biochemistry, or is he to assume that the reader is being introduced to physiology (except at the most elementary level) for the first time? The different authors of this joint work have adopted different methods. Writing on the biochemistry of muscle, D. Gilmour gives an epitome of present knowledge on glycolysis and oxidative metabolism in muscle in general, merely fitting into this background what little is known about the special biochemistry of the muscles of insects. K. D. Roeder adopts much the same treatment for the function of nerves and ganglia—though by including the Crustacea he has more to say that applies specifically to the nerves of arthropods.

To write a really good chapter or series of chapters in a book of this kind each author must have read and appreciated the literature of his subject. That certainly applies to most of the contributors: A. G. Richards on the cuticle, D. F. Waterhouse and M. F. Day on the digestive system, W. Trager on nutrition, V. G. Dethier on receptor organs—to mention a few names only. All these are authors well known for their researches in these fields and masters of their literature. Certain other chapters, such as those on respiration and excretion, are somewhat slighter.

Most of the authors have interpreted their task as calling for a pretty complete and balanced survey with only a modicum of critical discussion. J. B. Buck, for example, writing on the composition of the blood, has been at great pains to collect much scattered information and present it in a series of most valuable tables and charts. But others have adopted a more discursive method. L. E. Chadwick contributes three chapters on insect flight, amounting in all to nearly 100 pages. Clearly this is out of proportion to the rest—but these chapters are the best written in the whole book, and the general editor was certainly wise to permit this degree of freedom. The four chapters on growth, written by D. Bodenstein, are likewise somewhat discursive. But they are closely argued and show evidence of careful thinking. Even those readers who do not accept all the conclusions reached will find these chapters most stimulating. T. C. Schnierla contributes four chapters on insect behaviour. These are packed with information about the natural history of insects and make most interesting reading. But since the matter with which they deal is for the most part still beyond the grasp of the physiologist, they stand rather apart from the rest.

There are important topics, such as reproduction, insect pigments, light production and others, which are not included. For these reasons Prof. Roeder describes his book as a critical discussion rather than a complete review of insect physiology; but in fact most of the ground is covered fully and well.

V. B. WIGGLESWORTH

IDENTIFICATION KEYS TO THE BRITISH FAUNA AND FLORA

Bibliography of Key Works for the Identification of the British Fauna and Flora

Edited by Dr. John Smart and Dr. George Taylor. Pp. xi+126. (London: The Systematics Association, 1953.) 12*s*. 6*d*.

A SECOND edition of this very useful publication is welcome, including, as it does, many new references. The layout is clear and convenient and follows the same general plan as in the first edition, though the section on wood anatomy has been replaced by more useful ones on the anatomy of higher plants and the identification of pollen. Detailed criticism of such a work is difficult without an exceptionally wide knowledge of the literature. It must also be borne in mind that it is, after all, a list of works for assistance in the identification of the British fauna and flora, and from this point of view many important detailed works on particular groups may well be unsuitable for inclusion.

None the less, when due allowance has been made, there are some peculiar inclusions and omissions, which make this second edition a little disappointing. Space only allows a few random examples to be quoted here. It is strange that in the list of text-books on p. 3 there are works which, excellent in their day, are now quite out of date. Why, for

example, list Borradaile's "Manual of Zoology" and leave out Grove and Newell's "Animal Biology"? There is no reference to the two latest volumes of Hyman's work on the invertebrates published in 1951. Then again, in the general books on vertebrates, J. Z. Young's "The Life of the Vertebrates" and Romer's "The Vertebrate Body" are omitted. In the general books on Mammalia, Harrison Matthew's excellent account of British mammals in the New Naturalist series is not included.

There are also strange omissions in the lists of key works of the groups. In the Mollusca one would have thought that Thiele would have been given. The reference to Step, "Shell Life", is to the 1926 edition; but there was a revised edition in 1945.

These are a few examples; but they tend to weaken one's confidence in the comprehensiveness of the lists. The work gives an impression that the consultative net might have been cast a little wider among zoologists in general and the specialists in the various groups. Perhaps a third edition will not be too long delayed, and it is to be hoped that the editors in their laborious task will take comfort in the thought that they are earning the genuine gratitude of zoologists and botanists both at home and abroad.

The greatly extended list of references to monographs of special groups of flowering plants is a very valuable feature of the botanical section of this work, and one for which systematic botanists will be grateful. The exclusion of Schinz and Keller (given in the first edition) from the foreign books is to be regretted, and Raunkiaer's "Dansk Ekskursions-Flora" might well have been added. These, however, are minor blemishes in an admirable and comprehensive list of botanical works.

H. P. Moon
T. G. Tutin

"DOFLEIN'S PROTOZOA"

Lehrbuch der Protozoenkunde

Eine Darstellung der Naturgeschichte der Protozoen mit besonderer Berücksichtigung der parasitischen und pathogenen Formen. Sechste Auflage. Zweiter Teil: Spezielle Naturgeschichte der Protozoen. Zweite Hälfte: Sporozoa und Ciliophora. Begründet von Franz Doflein; fortgesetzt von Prof. Dr. Eduard Reichenow. Pp. iv+777–1214. (Jena: Gustav Fischer Verlag, 1953.) 23.50 D. marks.

THE first and more general part of this invaluable book has already been reviewed (*Nature*, 167, 829; 1951), and the commendations of that part then recorded apply also to the second part, which has been published as two paper-backed volumes, the first dealing with the Mastigophora and Rhizopoda and the second with the Sporozoa and Ciliophora. It is perhaps a mark of the advance of our knowledge of the Protozoa that 1,213 pages, each of them closely packed with detail, are required to record the essence of what we know about this remarkable group of organisms. The reader will marvel that one man can encompass so wide a range of detail; but Prof. E. Reichenow proves that he, at any rate, can, and every protozoologist will be grateful for the immense labour and care that he has put into this work. For there is no other book in any language that gives us all that "Doflein" does. Wenyon's great work, "Protozoology", with its wide range and emphasis on the pathogenic species, is unhappily out of print, and only the fortunate possessors of copies of it can enjoy and profit by its fine illustrations and its invaluable bibliography. It is a great pity that a revised edition of it has not been published.

But "Doflein" remains. Although it deals less fully than Wenyon did with the pathogenic species, this new edition will surely find a place in every biological library, and zoologists who work on the beautiful and thought-provoking non-pathogenic species will scarcely be able to do without it. They will welcome the return, in this second part of the book, of paper which gives back to the illustrations the quality they had in the earlier editions. Perhaps it will be possible to re-issue the first part on the same kind of paper. Though it increases the weight of the book, that is a justifiable price to pay for the added quality of the illustrations.

There is no space, in a brief review, to discuss in detail the contents of the book; nor is it likely that some readers will not find controversial statements somewhere or other in the three volumes, which cover so wide a field. A critic might, for example, select for discussion Prof. Reichenow's removal of the Theileridae and Babesidae from the Haemosporidia and his view that species of these families were not originally parasites of ticks. This view depends largely on work done by Prof. Reichenow himself and his colleagues. Logical though the views expressed will seem if this work and Prof. Reichenow's somewhat summary dismissal of earlier work are accepted, some readers will require further evidence before they will abandon the older views completely.

Whatever their criticisms, however, readers will be as grateful to Prof. Reichenow as they have been to Doflein, who created this great book. Other books on the Protozoa have appeared recently, and each of these has its own quality and value; but none has yet excelled "Doflein". English-speaking readers would no doubt be even more grateful if the book could be translated into English. This would not be a difficult task, because a feature of "Doflein" has always been the clear and relatively simple German in which it is written.

G. Lapage

TEXTILE FIBRES

The Identification of Textile Fibres

Qualitative and Quantitative Analysis of Fibre Blends. By Bruno Luniak. (Translated and Revised by the Author from the Second Edition of Communication No. 3 of the Department of Textile Engineering and Textile Industries at the Swiss Federal Institute of Technology in Zurich.) Pp. xiv+177+52 plates. (London: Sir Isaac Pitman and Sons, Ltd., 1953.) 45*s*. net.

MR. BRUNO LUNIAK wrote the first Swiss edition of his text-book whilst working with Prof. Honegger at the Technische Hochschule in Zurich. This was published in 1945. A second Swiss edition followed in 1949. The author is now working at the Linen Industry Research Association near Belfast, and encouraged by the success of his German version and by his British environment has translated his book into English; whilst doing this he has revised and enlarged the text, has increased the collection of photomicrographs and has added an index. All these changes have made the new

edition an improvement on its predecessors. It is rarely that the turn of a phrase suggests that the text is a translation.

The book is concerned with the identification of fibres and the determination of the composition of blends of fibres. Until the start of the Second World War there were only five different chemical types of fibres although they occurred in many modifications. In the past few years many new chemical types have been introduced. In some cases they are being used for giving the handle and appearance of older and more expensive fibres, as the fibres which were once called "artificial silk" were used as substitutes for natural silk. In other cases complicated blends of fibres are being turned out with the purpose of combining the good qualities and of overcoming the bad qualities of individual fibres. In other cases again the new fibres are making available textile qualities not previously obtainable. All these changes have increased both the range and difficulty of the analytical problems facing the textile technologist. As a result much greater interest is now being taken in this field. Mr. Luniak has provided a guide ; but, to continue the simile a little further, the extent of the field and the number of paths through it are increasing rapidly. This makes it difficult to write a book to include the very latest fibres and methods of analysis. Thus, for example, it has not been possible to include the chromatographic methods for identifying nylons.

A negligible prior knowledge has been assumed in the reader. Detailed instructions are given for carrying out the selected chemical, physical and microscopical tests. Any competent worker should be able to perform the first two immediately ; but a considerable amount of practice is required before microscopical examinations can be done even with the clearest instructions. The value of the text is increased by the inclusion of appreciations of the tests, which are summarized in synoptic tables and schemes of analysis.

The book can be recommended particularly for its comprehensive collection of excellent photomicrographs of natural and man-made fibres. These will be consulted by many readers who will not use the book as a laboratory manual. J. M. PRESTON

ABSTRACT SET THEORY

Abstract Set Theory

By Prof. Abraham A. Fraenkel. (Studies in Logic and the Foundations of Mathematics.) Pp. xii+480. (Amsterdam : North-Holland Publishing Co., 1953.) 38*f.* ; 76*s.*

MANY years ago the author published his "Einleitung in die Mengenlehre" (Springer, Berlin, 1919 ; third edition, 1928 ; reprinted Dover, New York, 1946). The present book follows, in external arrangement, the first half of the German treatise, but differs, not only through the principles introduced as basis of the theory, but also in the subject-matter and proofs in many sections. The definition by transfinite induction in §10,2, and the direct proof of general comparability by means of the axiom of choice in §11,1, are among subjects not treated in other text-books.

Chapter 1 is on elements and the concept of cardinal number. Most of this chapter, dealing with sets, denumerable sets, continuum, transcendental numbers, and cardinal numbers, could be read with great advantage by students reading for a mathematical honours degree.

Chapter 2 is concerned with equivalence and cardinals. The sections give definition of order, Cantor's theorem, the power set, the equivalence theorem, the problem of comparability, addition and multiplication of sets and of cardinals, inverse operations, inequalities between cardinals, the general concept of meet (inner product), Boolean algebra, exponentiation, infinitesimals and non-Archimedean domains.

Chapter 3 is on order and similarity, order types and ordinal numbers. There are sections on addition and multiplication of order types, linear sets of points, dense or continuous ordered sets, etc., well-ordered sets, transfinite induction, comparability of well-ordered sets, ordinal numbers, comparability of ordinals, alephs and initial numbers, the well-ordering theorem, the general comparability of sets and cardinals.

A noteworthy feature of the book is the extremely extensive bibliography, which must have taken many years to prepare. This will be of great value to readers. The book is excellently written and produced, and should become a standard text-book on the subject. R. G. COOKE

TEACHING DEAF CHILDREN TO SPEAK

Speech and the Deaf Child

By Irene R. Ewing and Dr. A. W. G. Ewing. Pp. xii+256+4 plates. (Manchester : Manchester University Press, 1954.) 18*s.* net.

THE chairman of the National College of Teachers of the Deaf recently summarized the present position in Great Britain as "approximately 5,000 deaf children in about fifty schools". These children are taught by some five hundred teachers, so that the educational provision made for them is comparable in size to one of the smaller local education authorities. They are educated by oral methods, speech and lip-reading forming the basis of the means of communication and, theoretically at least, every teacher of the deaf is a teacher of speech. The best teachers are usually too busy practising their craft to have time to record their methods for the benefit of their less successful colleagues, so it is very fortunate indeed that Dr. Irene Ewing, with the assistance of her husband, Prof. A. W. G. Ewing, has devoted the first years of her retirement to the production of this book. The Ewings form a unique team and are foremost among the workers in deaf education in Great Britain.

Although they begin by reviewing briefly the history of the teaching of speech to the deaf, they do not make sufficiently clear the confusion of methods that at present exists in the schools. Some teachers, using what is widely known as the 'analytic' method, still try to synthesize words and phrases from units of articulation ; others who prefer the so-called 'synthetic' method teach the children to speak complete words or breath-groups of sounds, and correct mistakes by analysis. It is generally recognized that these methods, usually imposed upon the children, result in an artificial form of speech which, at its best, is both laboured and monotonous. This may be attributed to a certain extent to two main

factors: not beginning early enough owing to inadequate provision of nursery schools or nursery classes for deaf children, and a tendency to isolate 'speech lessons' from 'language lessons'. In this book the Ewings propound a new approach, a 'genetic approach', to the teaching of speech to deaf children. They support their thesis by a comprehensive summary of new and proved methods used in the education of normal hearing children, and of the results of the many research projects carried out by them, or under their direction, in the University of Manchester.

Implicit in the 'genetic approach' is the belief that speech for the deaf child is primarily a form of mental growth, that it is a blossoming for which the mind and body are innately prepared, and will take place spontaneously in spite of the physical and mental handicap of deafness if a favourable social and emotional climate is provided. In a suitable environment, the first step is the development of a readiness for speech—a form of maturation analogous to 'reading readiness', and which, like it, takes place at different ages in different children. When a child is 'speech ready' the first words are produced spontaneously, indicating clearly that words are beginning to play a part in the life of his mind. They are the natural beginnings of speech as surely as are the first words of an ordinary child, and with assistance and guidance by a skilled teacher this speech can be developed until it becomes fluent and adequate for all normal purposes. Speech must be regarded as part of the normal life of the child, and all known means of developing it must be used. Auditory training has been proved to be of great value even for severely deaf children with hearing losses up to a hundred decibels.

The book is an excellent reference manual for all students and teachers of speech, and at the same time an encouragement to all parents and friends of deaf children. It is permeated with the inspiration and the firm belief in oral methods that Dr. Irene Ewing instilled into her students from the earliest days of the Department of Education of the Deaf in the University of Manchester, and it supports all that it claims by the production of living evidence. There will undoubtedly be a greater proportion of 'oral failures' than one would expect after reading the book, even after many years of practical application of the method described, and no doubt some readers will emphasize this point. The evidence given in the appendix also appears to be of a specific nature, and should be accepted with caution; but personal experience has shown that the results are astonishing. This is probably the most important contribution to the education of the deaf during the present century.

R. Askew

TIMBER DEVELOPMENT

Timber

Its Structure and Properties. By Dr. H. E. Desch. Third edition. Pp. xxiv+350+65 plates. (London: Macmillan and Co., Ltd., 1953.) 25*s*. net.

IT is a truism that increased efficiency in many branches of industry depends not so much on the acquisition of new technical knowledge as on the application of existing knowledge. In the timber-using industries there is certainly scope for improving the standard of production by having regard to the basic facts and principles of timber technology. The information is available for those who are in a position to make use of it; but the original sources of information are widely scattered, and considerable time and trouble may be involved in acquiring the relevant publications and assimilating their contents. A text-book of timber technology such as the volume under review can be very useful, therefore, to architects, surveyors, building contractors and works managers, as also to students and others who can afford to buy only a limited number of books. Efforts to increase the productivity of under-developed forest areas will not be fully effective unless we have the skill and knowledge to utilize the timber efficiently. The presentation of technical information in a convenient form can contribute to the well-ordered development of timber resources.

The author's primary object has been to provide the practical man with a simple, concise account of the structure, properties and methods of handling timber. The fact that a third edition has been called for so soon shows that the previous editions have been well received. In preparing the third edition the author has aimed at incorporating the more important results of research and development in the past five years. The text has been revised here and there, and new material has been added to the extent of sixty additional pages and ten more plates.

A feature of this new edition is a new chapter on the eradication of fungal and insect attack. It is generally agreed that decay and 'wood-worm' infestation in buildings are more prevalent to-day than formerly. This state of affairs has focused attention on insect and fungal pests of timber, and the publicity given to proprietary preservatives is tending to exaggerate the seriousness of the problem. The author has been at pains to analyse the alternative curative measures in an impartial manner. As he says, the three most common faults, when dealing with outbreaks of fungal attack, are to do too little investigation on the site, to carry out unnecessarily extensive replacements, and to ignore the fundamental cause, namely, a supply of moisture. Until the source of moisture is traced, the appropriate remedial measures cannot be laid down.

Although this book was originally written for the non-scientific reader, the author has had in mind also the needs of students preparing for examinations in timber technology. The sections on the classification of trees and the nomenclature of timbers have been rewritten in an attempt to clarify the difficulties laymen often experience with timber names. Some useful text-figures and plates illustrating structural features used in identification have been added. A note on the anisotropic swelling and shrinkage of wood, by R. D. Preston, has been included as an appendix to supplement the discussion of this subject in the body of the text. Having regard to recent advances in our knowledge of cell-wall structure, the author might have revised the section on the composition of the cell wall, which is based on what was known in 1938. With the advent of the electron microscope it is scarcely true to say, as is stated on p. 22, that the gap between observations made by the light microscope and X-rays can only be filled by inference and conjecture.

At 25*s*. this book is remarkably good value, especially when it is realized that it is twice the size of the first edition, published in 1938 at 12*s*. 6*d*.

B. J. Rendle

NEW TRIBOPHYSICS LABORATORY OF THE COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

By Dr. W. BOAS

Chief of the Division of Tribophysics, C.S.I.R.O., University of Melbourne

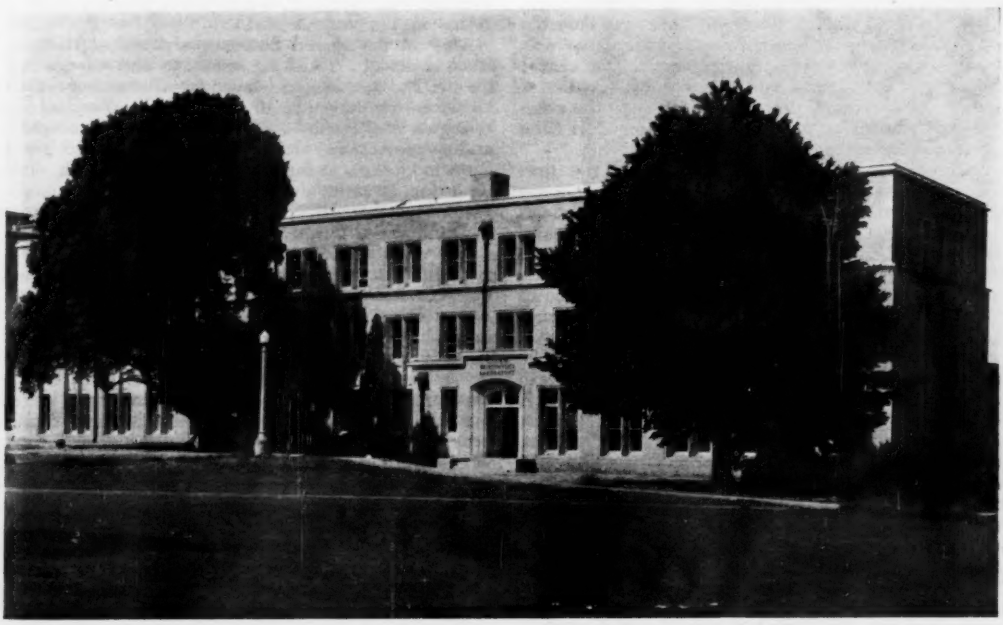
ABOUT a year ago an article in these columns described some of the work on metal physics being carried out by the Division of Tribophysics, Commonwealth Scientific and Industrial Research Organization, which was then just moving into a new building in the grounds of the University of Melbourne[1]. Since most of the teething troubles connected with this move have now been overcome and work is going on again normally, it may be of interest to describe the building and some of its equipment more fully.

The building is situated between the Chemistry and the Metallurgy Schools of the University. It is a steel-frame, brick-faced building, 160 ft. long and 40 ft. deep, with a total floor area of 21,000 sq. ft. It has three stories and a small basement. Provision has been made for the addition of further stories when required.

The basement houses boilers for hot water and central heating, a d.c. generator, an air compressor and the main a.c. distribution board. These services are distributed to all laboratories.

The ground floor contains a first-class workshop (40 ft. × 50 ft.), with a welding room and wood-working shop in which five engineering tradesmen and a carpenter make the apparatus required for research. Simple equipment is made from sketches; but more complicated apparatus from drawings prepared by a draughtsman under supervision of a trained mechanical engineer. Apart from the equipment usually made in such a workshop, a bearing-testing machine, X-ray diffraction cameras and a micro-indentation hardness tester[2] have been constructed here. The latter (load range 0·1–50 gm.) is being used in conjunction with one of the Vickers projection microscopes for the exact aiming of the indentation on a predetermined spot of a specimen. It has been employed in the investigation of plastic deformation of metals and particularly of two-phase alloys.

The bearing-testing machine is housed in a temperature-controlled enclosure in a large mechanical engineering laboratory situated on the ground floor. This machine measures the friction torque of various bearing-shaft combinations over a wide range of operating conditions which can be accurately controlled. The test bearing is loaded hydraulically through a parallelogram-type linkage which forms



Tribophysics Laboratory of the Commonwealth Scientific and Industrial Research Organization

the torque balance. In order to reduce friction in the linkage itself, flexure pivots are used. The test shaft is driven through a hydraulic transmission which provides stepless speed variation over a wide range of speeds. At maximum sensitivity the balance will detect torque changes of the order of 1 oz.-in. while transmitting a bearing load of 2,000 lb. Due to the constant temperature of the surroundings, constant heat-flow conditions are established in the bearing, and the accuracy of the balance is improved. With this equipment, the mechanisms of running-in, seizure and recovery from seizure have been investigated with two different bearing materials. Results indicate that running-in occurs most rapidly with the softer bearing material, which also gives more rapid recovery from partial seizure. The effect of journal, surface finish, clearance and other geometrical factors on bearing performance is being studied. High load capacity can only be obtained when a bearing is accurately aligned with respect to the load. The effect of calculated misaligning torques on a bearing will be measured in terms of increase in friction and reduction of load-carrying capacity.

In the ground floor there is a friction laboratory with the Bowden–Leben friction measuring apparatus on which the friction between selected pairs of materials can be measured over a range of temperatures and at predetermined loads and speeds. It is constantly used both by members of the Laboratory and by industrial scientists. There is also a small foundry with electric and gas furnaces and salt- and oil-baths for annealing and quenching, and a general store. The mechanical testing room houses a 30,000-lb. tension and compression testing machine, a Vickers hardness tester, an experimental rolling-mill and wire-drawing machine and a working bench with a small lathe and drill for the use of the research staff. The precision machines in the main workshop are reserved for the tradesmen. Finally, the ground floor contains a room with an isolated concrete floor slab suitable for vibration-sensitive instruments. Here, as was described previously[1], the energy stored in a metal during plastic deformation is being measured. A second calorimeter has now been built using the same electronic control apparatus to avoid the dead time during cooling to room temperature.

The main metallurgical laboratory on the first floor is arranged to allow easy flow of specimens through a series of rooms in which, after a rough preparation, they are annealed, electrolytically polished, etched and examined microscopically on either a Vickers projection microscope or a Bausch and Lomb metallograph. A laboratory-built X-ray set using sealed-off tubes is in an adjoining room. To avoid undue congestion, separate dark-rooms are provided for microscopes, X-ray sets and other apparatus requiring photographic work. A separate laboratory for copying and making lantern slides is located on the second floor. Offices for two research officers are of the unit size 10 ft. × 17 ft. and are on the first and second floors. The first-floor chemical laboratory houses work on reaction kinetics. Here the mechanism of oxidation of hydrocarbons and other organic compounds is being studied. This work has implications in the field of oxidation and deterioration of lubricating oils and other materials. The rate of oxidation depends on the gradual formation of intermediate substances, for example, peroxides and aldehydes, which have a catalysing effect on further reactions. The functions of phenolic additives to oils in inhibiting oxidation are also studied. It appears that they are only effective over a restricted range of concentration, and outside this they may even accelerate the reaction.

The remainder of the first floor is occupied by a drawing office and a library. Because of the proximity of the University Library, only the most frequently used thirty journals are obtained by subscription, and many more by loan, and the books are mostly on specialized subjects related to the research programme. Through the librarian, contact is maintained with translation and library services of the Commonwealth Scientific and Industrial Research Organization and universities.

The second floor contains an electronic workshop and testing room where, for example, amplifiers and scaling units for Geiger counters have been made. Radioactive tracers have been used for measuring the rate of self-diffusion in tin crystals and are now being employed in the study of surface diffusion. An X-ray Geiger counter spectrometer has been built to determine the shapes of diffraction lines from metal specimens and their change on deformation and annealing. This determination needs strictly monochromatic radiation, and the photographic method is not sufficiently sensitive for measuring X-ray intensities. An analysis of the line shapes gives information on the lattice imperfections in deformed metals.

The second-floor laboratories house the work on surface-chemistry and surface-physics. The structure and orientation of layers of fatty acids on metal surfaces are being studied with an electron diffraction camera, and an investigation of mechanical properties of fatty acid layers on water surfaces suggests that these are profoundly affected by the presence of metallic ions in the layer. Single crystals are used in work on catalytic activity. This eliminates the effects of crystal boundaries and also distinguishes between the effects of the different arrangements of atoms in the various surfaces.

Also on the second floor are a chemical store, an office reserved for visiting scientists and a large staff room. The last-named is used by all members of the Division for morning and afternoon tea and for colloquia and lectures. There are three blackboards and a projection screen, normally concealed under the window-sills at one end of the room, which, when used for lectures, comfortably holds about sixty. Here, together with the several other research groups in Melbourne, frequent metallurgical colloquia are held.

Of the total staff of fifty, about half have academic qualifications, and these had their initial training in a variety of subjects. Most of them take part in university teaching activities by lecturing, demonstrating or tutoring, and also give specialized assistance in the research programmes of various departments. In the complex research problems in pure science and perhaps more so in applied science, progress can be made only by an integrated group where interchange of ideas among the differently trained research workers takes place and experimental techniques developed in fields so far apart as chemical kinetics and metal physics are available. The need for a research staff with such a diversity of training was recognized early, and its composition has been a feature of the Division since its early days.

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STRUCTURAL CHANGES IN MUSCLE DURING CONTRACTION

Interference Microscopy of Living Muscle Fibres

By A. F. HUXLEY and Dr. R. NIEDERGERKE*

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IN spite of the numerous investigations which have been made into the changes of the striations of muscle when it contracts, there is little agreement at the present day on either the nature or the significance of these changes. Several factors contribute to this unsatisfactory position. The only contractions that could be studied in living muscle by the earlier workers[1] were the slow waves that occur in freshly isolated insect fibres; the broad striations and small diameter of these fibres are favourable for the interpretation of the microscope image, but the local nature of the contractions and the difficulty of applying passive stretch make it impossible to say whether the changes seen in the striations are accompaniments of 'activation', of tension development or of shortening. Observations on fixed material, whether with visible light or with the electron microscope, are also subject to this limitation as well as to the uncertainties in the effect of the fixative. Isolated fibres from frog muscle, however, give satisfactory propagated twitches and tetani, in which activation is complete very early after the first stimulus[2], while tension develops more slowly even if the contraction is isometric, and changes of length, both during stimulation and in the resting muscle, can be controlled by holding the tendon ends. This preparation therefore provides a basis for correlating visible changes with the sequence of events which take place during a contraction, and Buchthal and his colleagues[3] have endeavoured to exploit this possibility. Their conclusions are, however, open to the objection that they used the ordinary light microscope, which cannot be expected to provide a reliable image of unstained striations (alternate bands of high and low refractive index) the repeat distance of which is 2–3 μ, in a fibre of 50–100 μ diameter.

The phase-contrast microscope is equally unsuitable for a specimen of these dimensions; but an interference microscope in which the reference beam does not traverse the specimen would be expected to give a satisfactory 'optical section' of the fibre. An instrument of this kind was therefore built, the optical components being made to our specification by Messrs. R. and J. Beck. The basic principle was first described by Smith[4] (see also Huxley[5]), but further developments were incorporated to allow a water-immersion objective of n.a. 0·9 to be used. Gross refraction effects due to the cylindrical shape of the fibre were abolished by adding serum albumin to the Ringer's solution to bring its refractive index close to the average value for the fibre contents. A solid cone of illumination, n.a. 0·5–0·6, was always employed. Under these conditions, the fibre was completely invisible with ordinary light, but with the interference arrangement an excellent image of the striations (and also of sarcoplasm, nuclei and granules) was obtained. The contrast between *A*- (higher refractive index) and *I*-bands could be controlled or reversed by changing the background path-difference between the two beams; the measured widths of the bands were independent of this adjustment (Fig. 1). The fibre was photographed on moving film by a series of ten flashes from a discharge tube at intervals of about 20 msec., and could be stimulated by pulses of current synchronized with these flashes.

Passive stretch. The sarcomere length *s* could be changed by passive stretch or release from about 2·0 to 4·2 μ, the value at the extended length in the body being 2·5 μ[6]. Almost the whole of this change of length took place in the *I*-bands (Fig. 2). The measured width of each *A*-band remained constant at 1·4–1·5 μ except for a fall to about 1·3 μ as *s* was reduced in the range 2·5–2·0 μ; but this fall may well not be real, as its amount is less than the resolving power of the optical system. When a fibre was stretched rapidly (20–30 per cent in 5 msec.) the new ratio of *A*- to *I*-band widths appeared to be established without delay (less than 2 msec.).

Isometric twitches. Fibres were stimulated at a wide range of lengths with the tendon ends held stationary, and the twitch tensions, measured simultaneously with the *RCA* 5734 transducer, were normal. No change in the widths of the bands could be detected, except that when slight shortening of the region of the fibre in the field of view took place the changes were similar to those in isotonic shortening of the same extent.

Isotonic contractions (Fig. 3). Fibres were photographed during twitches and short tetani under isotonic conditions, with various initial lengths up to 3·2 μ per sarcomere. As in passive shortening, it was the *I*-bands that became narrower, the band-width

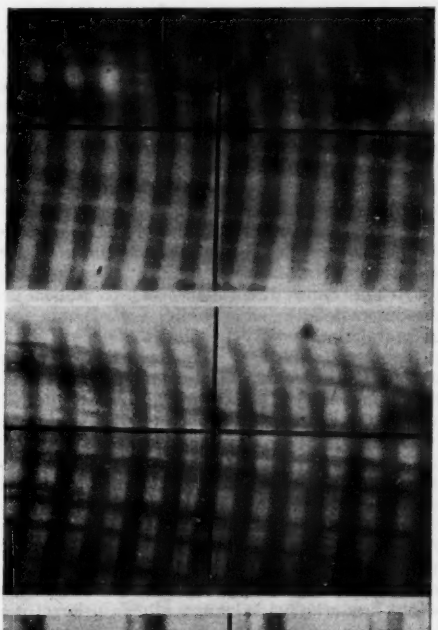

Fig. 1. Muscle fibre in negative (*a*) and positive (*b*) contrast. *A*-bands (higher refractive index) light in (*a*), dark in (*b*). Note that the threads of sarcoplasm have a refractive index slightly higher than even the *A*-bands. Sarcomere length, 3·0 μ

* George Henry Lewes Student; with support from the Deutsche Forschungsgemeinschaft.

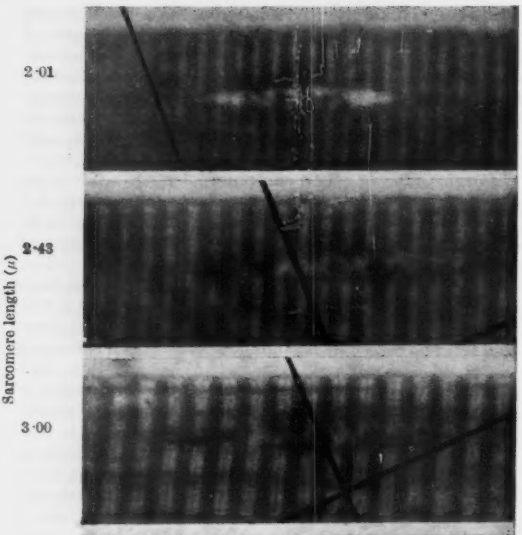

Fig. 2. Passive stretch of a muscle fibre. Positive contrast (*A*-bands dark). Sarcomere lengths indicated beside the photographs. Almost all the change of length is in the *I*-bands (light)

of *A* being constant down to a sarcomere length of $s = 2{\cdot}5\ \mu$ and falling only slightly down to $s = 2{\cdot}0\ \mu$. On further shortening, studied largely by ciné photography of slow contractions induced by constant-current stimulation, *A*-band width decreased definitely in all cases; but there were additional phenomena which were not the same in every experiment. The following sets of changes were observed on several occasions:

(*a*) Striations became extremely faint on shortening beyond a sarcomere length of about $1{\cdot}8\ \mu$ (cf. Speidel[7]).

(*b*) The dense band narrowed to about half the sarcomere length, after which both bands narrowed in proportion.

(*c*) At $s = 1{\cdot}8\ \mu$, a very narrow dense band was visible at the centre of the former *A*-band, and on shortening to $s = 1{\cdot}7\ \mu$ additional dense lines appeared midway between these (cf. Jordan's observations on stained preparations[8]).

The similarity of the changes during passive shortening and during isotonic contraction, and the absence of change during isometric twitches, show that the changes in the ratio of widths of the *A*- and *I*-band depend simply on the length of the fibre, and are unaffected by 'activation' or by tension development as such. The approximate constancy of *A*-band width under a wide range of conditions (including shortening within the physiological range) agrees with the observations of Krause and of Engelmann[1], and also with those of H. E. Huxley and J. Hanson on separated myofibrils reported in the accompanying communication, though it is in conflict with the results of Buchthal *et al.*[3]. The natural conclusion, that the material which gives the *A*-bands their high refractive index and also their birefringence is in the form of submicroscopic rods of definite length, was put forward by Krause, and receives strong support from the observations reported here. The identification of this material as myosin[9], and the existence of filaments (presumably actin) extending through the *I*-bands and into the adjacent *A*-bands, as shown in many electron microscope studies, makes very attractive the hypothesis that during contraction the actin filaments are drawn into the *A*-bands, between the rodlets of myosin. (This point of view was reached independently by ourselves and by H. E. Huxley and Jean Hanson in the summer of 1953. It has already been mentioned by one of those authors[10] and is further discussed by them in the accompanying article.)

If a relative force between actin and myosin is generated at each of a series of points in the region of overlap in each sarcomere, then the tension per filament should be proportional to the number of these points, and therefore to the width of this zone of overlap. If the myosin rods are $1{\cdot}5\ \mu$ long and the actin filaments $2{\cdot}0\ \mu$, the isometric tetanus tension should fall linearly as the fibre is stretched over the

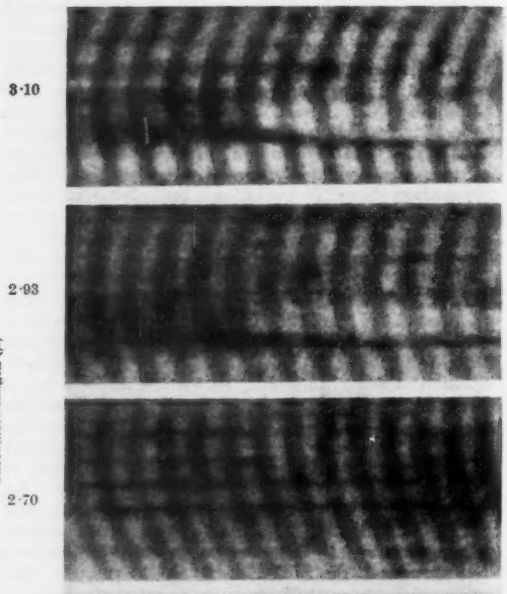

Fig. 3. Muscle fibre during a short isotonic tetanus. Positive contrast (*A*-bands dark). As in passive stretch (Fig. 2), the *A*-bands remain of almost constant width

range of sarcomere lengths from 2·0 to 3·5 μ; this is in fair agreement with observation[11]. In arthropod striated muscle, there is a wide range of sarcomere lengths *in situ*, and narrowness of striation appears to be correlated with high speed of contraction[12]. This would be expected if the relative velocity between actin filaments and myosin rods in any one zone of overlap were the same for muscles of different sarcomere lengths, since the number of sarcomeres shortening in series per unit length is inversely proportional to sarcomere length. On this basis it would also be expected that the muscle with longer sarcomeres would be capable of producing a greater tension, but we are not aware of any experimental results on this point.

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Changes in the Cross-Striations of Muscle during Contraction and Stretch and their Structural Interpretation

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In recent papers[1-3], we have described evidence concerning the location and arrangement of the two principal structural proteins, actin and myosin, in striated muscle at rest length. This evidence indicates that myosin is located in the anisotropic or *A*-bands, in the form of longitudinal filaments about 110 A. in diameter, spaced out in a hexagonal array 440 A. apart; these filaments are continuous from end to end of the *A*-band, and appear to be responsible for its high density and birefringence. Actin, on the other hand, is present in both the *A*-bands and the relatively isotropic or *I*-bands, in the form of filaments about 40 A. in diameter; these extend from the *Z*-lines, through the *I*-bands, and into the *A*-bands, where they lie between the myosin filaments and terminate on either side of the *H*-zone; the myosin filaments seem to have a somewhat greater thickness in this zone. Hasselbach[4] has reached similar conclusions about the location of actin and myosin, though his concept of the details of their arrangement is different from ours. We shall now describe evidence that during stretch, and during contraction down to about 65 per cent of rest length, the length of the *A*-bands remains constant within the limits of accuracy of our measurements (5–10 per cent), the changes in length of the muscle being taken up by changes in the length of the *I*-bands alone; further shortening beyond the point where the *I*-bands vanish (about 65 per cent of the rest length) is accompanied by the formation of contraction bands where the *A*-bands have come into contact with the *Z*-lines. These changes appear to take place by a process in which actin filaments slide out of or into the parallel array of myosin filaments in the *A*-bands; as shortening proceeds, the actin filaments fold up in the *A*-band, and this folding continues after the *I*-bands have been fully retracted. The myosin filaments remain at constant length until forced to shorten by excessive contraction of the sarcomeres.

Previous work on the changes in cross-striation accompanying stretch or contraction (reviewed by Jordan[8] and Buchthal, Knappeis and Lindhard[3]) has given results which in general we consider to be unreliable, for the following reasons. Observations made on intact muscle fibres in conventional light microscopes are liable to be misleading because of optical artefacts due to the thickness of the fibres. (This difficulty has been surmounted by the technique described by A. F. Huxley and R. Niedergerke in the accompanying paper.) Furthermore, normal contraction is so rapid that the changes taking place *during* the process are difficult to see and record. If fixed and sectioned material is used, it is possible to avoid optical artefacts and the necessity for rapid observation, but other kinds of artefacts are introduced. In spite of all these considerations, a number of workers, notably Speidel[7], have given accounts of changes of band pattern during stretch and contraction which we recognize as generally correct; but they do not establish the details of the changes with the precision necessary for satisfactory interpretation.

In order to avoid optical artefacts, we have used isolated myofibrils about 2 μ in diameter prepared by blending glycerol-extracted rabbit psoas muscle[5]. They are admirable objects for high-resolution microscopy in phase-contrast illumination or polarized light, and will contract when treated with adenosine triphosphate[9]. This contraction is a much slower process than contraction *in vivo*, and therefore provides favourable circumstances for detailed observation of the band changes taking place. The evidence that the mechanism of contraction in glycerol-extracted muscle treated with adenosine triphosphate is similar to that of normal contraction in living muscle has already been adequately discussed by Szent-Györgyi[8] and Weber and Portzehl[10]. We have also devised a simple technique for stretching isolated fibrils during observation. A suspension of fibrils, mounted as a very thin layer on a slide under a coverslip, is examined in the microscope until a fibril is found with one end embedded in a fibre fragment adhering to the coverslip, and its other end in a fragment attached to the slide. Movement of the coverslip in the appropriate direction will then produce the desired stretch or will permit the fibril to shorten if adenosine triphosphate is present. Very small movements can be produced with great ease by gentle pressure on the edge of the coverslip, for the thin layer of liquid provides smooth and highly viscous lubrication.

Photographs used for measurement were taken on microfile film at a magnification of × 370 or × 550, and an apochromatic phase-contrast objective of n.a. 1·15 was employed.

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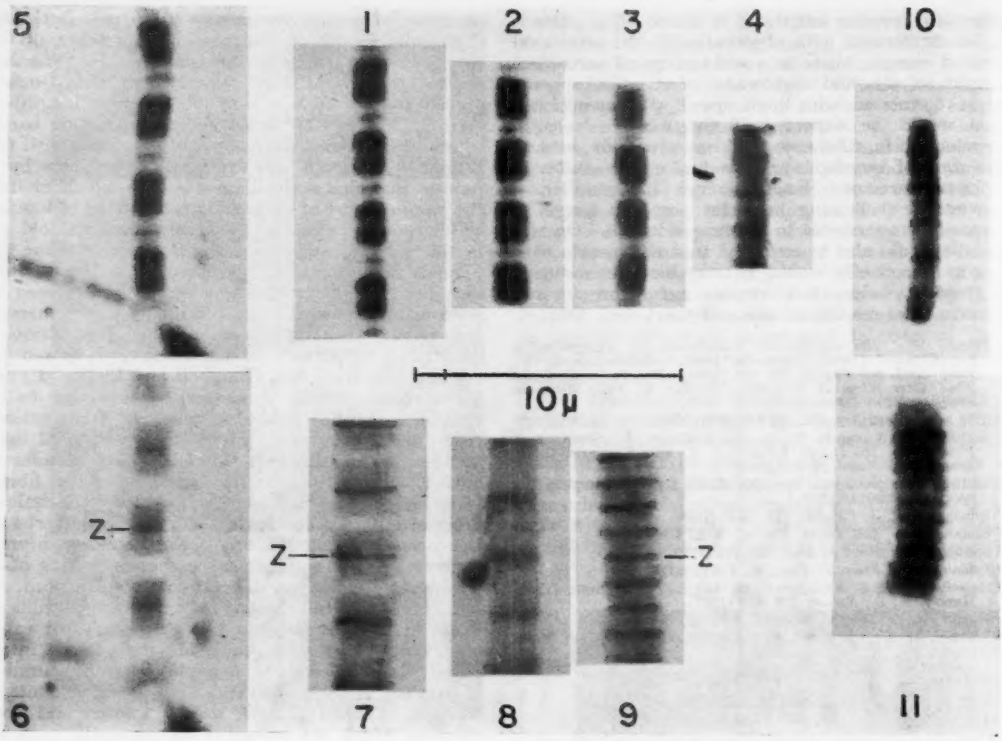

Myofibrils photographed in phase contrast. Magnification, 4,000 ×. Photographs of extracted fibrils are printed so as to give adequate contrast, and the fibrils are in fact much less dense than they appear here

Figs. 1–4. The same four sarcomeres of one fibril photographed during contraction induced by adenosine triphosphate from rest length down to 50 per cent rest length, when contraction bands have formed

Figs. 5 and 6. Stretched fibril (115 per cent rest length) before (Fig. 5) and after (Fig. 6) extraction of myosin

Figs. 7, 8 and 9. Fibrils after extraction of myosin. Fig. 7: rest length. Fig. 8: 90 per cent rest length. Fig. 9: 75 per cent rest length

Figs. 10 and 11. Fibril with contraction bands (50 per cent rest length) before (Fig. 10) and after (Fig. 11) extraction of myosin

Contraction

We have studied and obtained photographic records of the details of contraction in the following systems:

(1) Fibrils contracting freely at room temperature (about 22° C.) in 5×10^{-4} *M* adenosine triphosphate, 0·1 *M* potassium chloride, 10^{-3} *M* magnesium chloride, *p*H 7·0.

(2) Fibrils contracting freely at room temperature in a series of steps achieved by irrigating them with a succession of small amounts of a very dilute solution of adenosine triphosphate (5×10^{-6} *M*), irrigation being stopped as soon as the required degree of shortening had taken place.

(3) Fibrils contracting freely at a low temperature (about 2° C.) in adenosine triphosphate in the almost complete absence of magnesium ions, when shortening takes place very slowly.

(4) Fibrils contracting as in (1) but held at both ends so that shortening is controlled.

Cinephotography was used for system 1; but in systems 2–4 it was possible to take 'still' photographs on fine-grain film. In the first three systems the fibrils were contracting against virtually zero load and showed identical changes of band pattern. System 4 provided information about isometric contraction, and it was found that the changes of band pattern differed in some details from those recorded during contraction against zero load.

During contraction of single fibrils against zero load, we have observed the following changes in band patterns (illustrated in Figs. 1–4). The *I*-bands shorten from a resting length of approximately 0·8 μ until they disappear completely. During this process, the length of the *A*-bands remains constant at approximately 1·5 μ. Changes of density within the *A*-band do, however, occur. The *H*-zone, originally of low density, first becomes indistinguishable from the rest of the *A*-band, and is then replaced (at about 85 per cent rest length) by a narrow zone which is denser than the rest of the *A*-band. At a slightly shorter sarcomere length (about 80 per cent rest length), a very dense line becomes visible at either end of the *A*-band. The overall density of the *A*-bands decreases as the fibril diameter increases during shortening. When the *I*-bands disappear at about 65 per cent rest length, contraction bands form at the lines of contact of adjacent *A*-bands. It is interesting to note that contraction down to 65 per cent of the rest length covers the usual range of physiological shortening. With the further shortening which can usually be produced in isolated fibrils, the contraction bands become denser; during this process (or in some cases just before the *I*-bands disappear) the dense zone in the middle of the sarcomere

splits into two lines which merge with the incoming contraction bands at approximately 30 per cent rest length.

Fibrils prepared from muscle which was allowed to shorten to equilibrium length (~ 80 per cent rest length) before glycerol extraction usually lack the *H*-zones characteristic of rest-length fibrils, and have correspondingly shorter sarcomere lengths. Suspensions of untreated fibrils also include some specimens with sarcomere lengths down to about 65 per cent of the rest length. Contraction presumably took place while the muscle was still excitable before glycerol extraction. Such fibrils exhibit the same characteristic band patterns and band lengths as those recorded for each sarcomere length during contraction induced by adenosine triphosphate.

During isometric contraction of isolated fibrils in adenosine triphosphate (achieved by holding the ends of the fibrils) the lengths of the *A*- and *I*-bands do not change. However, a narrow dark zone appears in the centre of the *A*-band (as in free contraction) as though some translation of material within the sarcomere were taking place, presumably accompanied by stretch of a series elastic component. This phenomenon is not observed in fibrils that are attached along their whole length to the coverslip or slide.

Stretch

We have found that isolated fibrils can stretch by two different processes, depending on whether the fibril has been 'plasticized'[10], or whether it is being extended while in rigor or while it is exerting a large contractile force. In each case, however, only the *I*-bands change in length; the *A*-bands remain at constant length.

If fibrils are stretched at 2° C., in the absence of magnesium ions and in the presence of rather high concentrations of adenosine triphosphate (about 10^{-3} *M*) —conditions which favour the plasticizing action of adenosine triphosphate rather than its contracting effect[10]—then the *I*-bands increase in length. The length of the *A*-band remains unchanged, but its central region becomes somewhat less dense, as though the *H*-zone were lengthening; the length of this less dense region increases as stretch proceeds. This process is perfectly reversible: stretched fibrils can be allowed to shorten until contraction bands form, and then re-extended.

If fibrils are stretched without any previous treatment, or in the presence of 10^{-4} *M* adenosine triphosphate and 10^{-3} *M* magnesium chloride at room temperature, when contraction is strong, then it is still the *I*-bands alone which increase in length. However, this increase is now not accompanied by any decrease in density of the central part of the *A*-band; on the other hand, the *Z*-lines now become appreciably fainter in spite of the fact that the diameter of the fibril is decreasing. (In the first type of stretch the *Z*-lines remain normal.) This suggests that some stretch is occurring in the region of the *Z*-line. This type of extension is also reversible.

We believe that the second type of stretch extends the series elastic component (Hill[11]), whereas the first type of stretch produces semi-plastic extension as in relaxed muscle.

The appearance of stretched muscle has also been investigated by examining fibrils prepared from fibres which were stretched immediately after removal from the rabbit. Such preparations contain a very high proportion of fibrils with long *I*-bands and the characteristic long zone of low density in the middle of each *A*-band (Fig. 5). We have made several hundred measurements of the lengths of *A*- and *I*-bands on such fibrils and can detect no significant difference in the lengths of *A*-bands from those found in fibrils with the shorter *I*-bands typical of rest length. These observations provide some evidence that the band pattern changes associated with stretch in whole living muscle fibres are similar to those seen in isolated fibrils which have been plasticized. Much more powerful evidence for this is described in the accompanying paper by A. F. Huxley and R. Niedergerke, to whom we are indebted for early reports of their results.

Myosin Extraction after Stretch and after Contraction

We have extracted myosin from fibrils of different sarcomere lengths by methods similar to those described previously[3]. In these earlier studies a dark zone always remained in the centre of the *A*-band of rest-length fibrils after extraction, although the density of the rest of the *A*-band was reduced to that of the *I*-band. Electron microscope studies showed that the dark band still contained the thicker filaments which elsewhere in the *A*-band had been removed. Hasselbach[4] has shown that this dark band disappears during prolonged myosin extraction, and we have found that this process can be accelerated by using 0·1 *M* pyrophosphate, 10^{-3} *M* magnesium chloride, *p*H 7·0. Accordingly, in the present studies we have employed this method for extracting all the myosin.

The appearance of fibrils extracted at different degrees of stretch and contraction is shown in Figs. 6–9 and 11. The 'ghost' fibril consists of a faint backbone structure (which we believe consists largely of actin) the density of which is about the same as that of the original *I*-bands; the *Z*-lines are also still visible. In fibrils at rest length, an apparent gap is observed in place of the original *H*-zone (Fig. 7). In stretched fibrils, where there was originally a longer zone of low density in the centre of the *A*-band, the length of the gap is correspondingly greater (Fig. 6). The ghost fibrils are, however, still structurally continuous; stretched fibrils shorten spontaneously to a little less than rest length during extraction unless stuck to slide or coverslip; they may be reversibly extended again. This can be done with great ease, and it is apparent that only a very weak force opposes such a stretch; the gap elongates in the process, but the length of the material extending from the *Z*-line to the edge of the gap remains constant; that is, no stretching of an elastic component in the *I*-band region now occurs.

The ghosts obtained from contracted fibrils in which the *H*-zones had just disappeared have no gaps in the centres of the sarcomeres (Fig. 8). Fibrils which had shortened until dark lines appeared in the middle of the *A*-bands retain these lines after thorough extraction of myosin (Fig. 9); these dark lines are also present in ghosts from more strongly contracted fibrils (Fig. 11).

None of these 'ghosts' will contract when treated with adenosine triphosphate.

Electron Microscopy

We have made a preliminary examination in the electron microscope of thin sections of stretched,

contracted and myosin-extracted muscles prepared by the methods described elsewhere[9,12], and we have obtained results which, so far as they go, are in complete agreement with those obtained by light microscopy. This technique does not readily permit of reliable measurements of the lengths of sarcomeres or bands, for, apart from fixation artefacts, an unknown amount of compression is always present in even the best thin sections. In sections of stretched muscle, the majority of the *A*-bands show the characteristic long central region of low density (also observed by Philpott and Szent-Györgyi[13]); we find that the secondary array of thin (40 A.) filaments[8] is absent from this zone. In stretched muscle which has been subjected to myosin extraction the thick (110 A.) primary filaments are absent, and gaps apparently exist between the groups of thin (40 A.) filaments associated with successive *Z*-lines. In sections of glycerol-extracted muscle contracted in adenosine triphosphate, we have observed the same variety of band patterns seen in the light microscope. Up to the point where the *I*-bands disappear, the primary array of thick filaments remains apparently unchanged; and when contraction bands have been formed, the primary filaments between them are still straight. Our fixation of the secondary filaments has not yet been sufficiently good to allow us to describe adequately any changes, apart from translation into the *A*-bands, that may have taken place in them during contraction. During stretch of living muscle, however, the approximately 400-A. axial period seems to remain unchanged; a similar result was obtained by low-angle X-ray diffraction studies[1].

Conclusions

We believe that most of these changes in the cross-striations of muscle during stretch and contraction may be adequately described in terms of the following fairly simple model: The backbone of the muscle fibril is made up of actin filaments which extend from the *Z*-line up to one side of the *H*-zone, where they are attached to an elastic component (*not* the series elastic component) which for convenience we will call the *S*-filaments. The *S*-filaments provide continuity between the set of actin filaments associated with one *Z*-line and that associated with the next. The series elastic component is provided either by the actin filaments themselves or, more probably, by their mode of attachment to the *Z*-line. Myosin filaments extend from one end of the *A*-band, through the *H*-zone, to the other end of the *A*-band, and their length is unaltered by stretch or by contraction down to the point where the sarcomere length is equal to the length of the *A*-band; when contraction beyond this point takes place, the ends of the myosin filaments fold up and contraction bands form. Thus myosin and actin filaments lie side by side in the *A*-band and, in the absence of adenosine triphosphate, cross-linkages will form between them; the *S*-filaments are attached to the myosin filaments in the centre of the *A*-band by some more permanent cross-linkages.

In this model, plastic stretch takes place when the actin filaments are partly withdrawn from the *A*-band, leaving a long lighter central region and stretching the *S*-filaments in the process. Only the *I*-bands and the *H*-zones increase in length, the length of *A*-band remaining constant. This process would be inhibited by cross-linkages between the actin and myosin filaments; there is good evidence[10] that muscles are only readily extensible when such linkages are absent. When they are present, stretch would take place by extension of the series elastic component; in our model, this would again lead to an increase in the length of the *I*-band, but in this case no change in the length of the *H*-zone would take place. Contraction takes place in this model when the actin filaments are drawn into the *A*-band (until the *H*-zone is filled up) and are then folded up in some way to produce more extensive shortening. Thus, when the model is allowed to shorten, only the *I*-bands decrease in length until adjacent *A*-bands are pulled into contact with the *Z*-lines. When contraction is isometric, translation of actin filaments into the *A*-bands is accompanied by stretch of the series elastic component. It will be seen that in both stretch and contraction the behaviour of this model reproduces the observed behaviour of muscle quite faithfully.

A possible driving force for contraction in this model might be the formation of actin–myosin linkages when adenosine triphosphate, having previously displaced actin from myosin, is enzymatically split by the myosin. In this way, the actin filaments might be drawn into the array of myosin filaments in order to present to them as many active groups for actomyosin formation as possible; furthermore, if the structure of actin is such that a greater number of active groups could be opposed to those on the myosin by, for example, a coiling of the actin filaments, then even greater degrees of shortening could be produced by essentially the same mechanism. The model will remain contracted as long as the splitting of adenosine triphosphate continues; it will relax if the splitting stops and more adenosine triphosphate diffuses in, breaking actomyosin linkages and allowing the muscle to be re-extended. However, our results by no means require that contraction and relaxation be brought about in this way; and indeed, in the light of recent studies on actin[14,15], it would not be surprising if other processes are also involved. Furthermore, our results cannot exclude the possibility that repetitive configurational changes take place within the myosin filaments during contraction, unaccompanied by any overall change in the length of those filaments, and that these changes somehow bring about the observed movement of the actin filaments into the *A*-band.

These results will be described in greater detail elsewhere. We are much indebted to Prof. Francis O. Schmitt for his encouragement of this work, and to the Commonwealth Fund and the Rockefeller Foundation for their support.

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OBITUARY

Sir David Chadwick, K.C.M.G., C.S.I., C.I.E.

THE death of Sir David Chadwick on April 26 will be mourned throughout the British Commonwealth and indeed beyond. A man of vision and infectious enthusiasm, and with the great gift of lucid and persuasive presentation, he effected, quietly and imperceptibly except to a few initiates, a small but veritable revolution in Commonwealth relations.

Chadwick left the Indian Civil Service for family reasons while still in full vigour and with membership of the Viceroy's Council in prospect. He was forthwith, in 1927, appointed secretary of the Imperial Economic Committee. In the following year he added to this post the secretaryship of the Council of the Imperial Agricultural Bureaux. Indeed, he was the skilful midwife and patient nurse, if not the begetter of this organization, which is remarkable not only for the acknowledged excellence of its work in making available to the Commonwealth and the world at large the progress of research in the agricultural sciences, but also because it exemplified in its origin an entirely novel form of intergovernmental co-operation.

The Imperial Economic Committee, when Chadwick came to it, was, despite its name, a 'Whitehall baby', created and financed by H.M. Government in the United Kingdom. True, the other Governments of the Commonwealth were invited to nominate, and did nominate, representatives to sit on the Committee, and the Committee's reports were addressed to all the Governments. Nevertheless, the Committee was, in fact, solely the responsibility of the United Kingdom Government. But when the idea of the Imperial Agricultural Bureaux was conceived, Chadwick accomplished a veritable *tour de force*. Recognizing the advance in Commonwealth relations implicit in the proceedings of the 1926 Imperial Conference, which ultimately was made explicit in the Statute of Westminster, Chadwick drafted a scheme whereby all the Commonwealth Governments were to become true partners in erecting, financing and administering the new organization. Then he circulated his draft and expounded it with a persuasiveness and enthusiasm that begat conviction. So was born, largely by the efforts of one man, a unique Commonwealth partnership.

A few years later, when after the Ottawa Conference the Empire Marketing Board was disbanded, the Commonwealth Governments asked the Imperial Economic Committee to carry on a large part of the Board's intelligence services as a co-operative Commonwealth enterprise, and decided to reconstitute the Committee on the Imperial Agricultural Bureaux model. Thus came into being a second Commonwealth co-operative organ. With an expanded but remarkably economical staff, Chadwick carried out the Committee's old and new functions with consummate success. The output of regular intelligence reports, weekly, monthly, quarterly and annually, and of *ad hoc* reports and world surveys, was interrupted by the outbreak of war. The work of the Imperial Agricultural Bureaux, however, was continued, and Chadwick remained at his post with a skeleton staff until peace returned and he could at last hand on the torch to his successors.

Chadwick had a passionate faith in the British Commonwealth—a faith that moved mountains. His shade will walk the Elysian fields happily and buoyantly, if the two Commonwealth organs, which owe him so much, continue to serve the Commonwealth and constitute for him a monument *aere perennius*.

ALAN GREEN

NEWS and VIEWS

Royal Society: New Foreign Members

THE election of Prof. Karl von Frisch, Prof. Otto Loewi, Prof. Karl Manne Georg Siegbahn and Dr. Otto Struve to foreign membership of the Royal Society was announced in *Nature* of May 8. The following notes survey very briefly the main fields of their scientific activities.

Prof. Karl von Frisch

THE work of Prof. Karl von Frisch, of Munich, has influenced our whole understanding of the chemical and visual senses of insects and other animals. In the past few years he has made outstanding contributions to our knowledge of behaviour with his studies on the methods of communication and orientation among worker honey bees. In 1919 von Frisch showed that bees could be trained to distinguish with high accuracy a great many different tastes and odours, and that the chemical senses of bees are in some respects similar to those of vertebrates. By a long series of conditioning experiments, he also showed that bees have well-developed colour vision, and he was able to establish with a considerable degree of accuracy the wave-lengths to which bees' eyes are sensitive. In 1923 he showed that information about the existence of rich sources of food discovered by a foraging worker could be communicated to other members of the colony by means of a characteristic form of dance executed on the surface of the comb. This was followed by a series of papers (1946–51), from which it appeared that the methods of communication and orientation among bees reach a degree of precision and complexity hitherto undreamt of. He discovered the methods by which bees estimate the distance of the source and showed how they interpret information supplied by the returning workers. He established that landmarks are utilized for orientation, and above all he showed that the bee's eye is sensitive both to the plane and intensity of the polarization of light reflected from the unclouded sky. Bees are able to use these means of orientation even when the sun itself is invisible, and to retain in their memories, for a period of days, a pattern of polarization presented by the sky at a given time of day and to take into account the alteration of this pattern with the change in position of the sun.

Prof. Otto Loewi

PROF. OTTO LOEWI is best known for his work on the liberation of pharmacologically active substances at nerve endings. The similarity between the actions of certain drugs and the actions of autonomic nerves had suggested to various people that autonomic nerves might actually liberate drugs at their endings, but it was not until 1921 that Loewi, who was then professor of pharmacology in Graz, overcame the formidable difficulties of actually proving this to be

the case and convincing the sceptics who were unable to repeat his experiments. He showed that sympathetic nerves and parasympathetic nerves liberated substances resembling adrenaline and acetylcholine, respectively. He showed that the latter substance was destroyed by an enzyme and that this enzyme was inhibited by physostigmine, and as the years went by and others became interested, he made many other discoveries in this field. He was awarded a Nobel Prize in 1936 jointly with Sir Henry Dale for this work. He left Austria when the Nazis arrived and now lives in New York, where he celebrated his eightieth birthday last year. He is still an active thinker, full of new ideas and able to take the lead at great gatherings such as the symposium in Philadelphia in September 1953, which was entirely devoted to the phenomenon to which he gave the name of neurohumoral transmission. The account of this symposium occupies 130 pages in *Pharmacological Reviews*.

Prof. K. M. G. Siegbahn

The discovery of the diffraction of X-rays by crystals, by Laue, Friedrich and Knipping in 1912, opened up two main avenues in physics—the investigation of the structure of matter on the atomic scale, and the study of the structure of atoms themselves. This latter subject originated in the work of Moseley, but in its detailed exploration and development the name of Siegbahn is pre-eminent; he made it his aim to measure as precisely as possible the wavelengths of all the lines in the X-ray spectra of the elements, and his results gave complete support to the Bohr model of the atom and enabled orbital energies to be precisely measured. He verified the existence of Barkla's K and L radiations, and discovered a further series of lines—the M radiation. His work was carried out with typical Swedish thoroughness; he worked to an accuracy of a second of arc when others were satisfied with minutes; he made X-ray tubes which served as models for other departments; he made significant contributions to the design of vacuum pumps, in particular the molecular pump. All types of precision instruments seem to delight him. His own work reached a peak in 1916; but since then he and his various schools at Lund, Uppsala and Stockholm—where he was made professor of physics in 1920, 1923 and 1930, respectively—have exerted a profound influence on the subject of the spectroscopy of X-rays, particularly, in recent years, of soft X-rays. His book, "Spektroskopie der Röntgenstrahlen", which appeared in 1924 and was translated into English in 1925, is still the standard text-book on the subject. Prof. Siegbahn was awarded the Nobel Prize for Physics in 1924, the Hughes Medal of the Royal Society in 1934 and the Rumford Medal in 1940. It is pleasant that his connexions with Britain should now be strengthened by his election as a foreign member of the Royal Society.

Prof. Otto Struve

Prof. Otto Struve is of the fourth generation of distinguished astronomers. He is a Gold Medallist of the Royal Astronomical Society, as were his great-grandfather, his grandfather and his uncle before him. His father was professor of astronomy in the University of Kharkov and died in 1920. In 1923 Otto Struve published his first astronomical paper on "The Double Star 9 Argus", from observations made with the Bruce spectrograph of the Yerkes Observatory. From then onwards there has flowed from his pen a series of papers on spectroscopic binaries, the radial velocities of B-type stars, the relation between the intensity of the interstellar K line with stellar distance, and the absolute magnitudes of B-type stars; the contours of lines in rapidly rotating stars was also examined by him. Other subjects that he has treated in numerous papers have included shell stars and the dilution of radiation from a central star passing through outer layers of gas, stars with peculiar spectra, an explanation of anomalies in the spectra of binary stars in terms of streams of gas passing between the stars, and the brightness of galactic nebulæ. His output has been enormous despite heavy administrative labours as director of the Yerkes Observatory since 1932 and in addition of the McDonald Observatory since 1939. He has recently retired to a less strenuous (administratively speaking) post as director of a research department in the University of California at Berkeley, but happily he continues to publish his researches. He is at the moment president of the International Astronomical Union.

American Academy of Arts and Sciences

At the annual meeting of the American Academy of Arts and Sciences, held in Boston on May 12, Prof. J. E. Burchard, professor of humanities and dean of the School of Humanities and Social Studies, Massachusetts Institute of Technology, was elected president of the Academy. The following, among others, were elected foreign honorary members: Prof. N. F. Mott, Cavendish professor of experimental physics, University of Cambridge; Sir Edward Bullard, director of the National Physical Laboratory, Teddington; Sir Harold Jeffreys, Plumian professor of astronomy and experimental philosophy, University of Cambridge; Prof. A. von Muralt, professor of physiology, University of Berne; Dr. W. J. Schmidt, director of the Zoological Institute, Giessen; and Sir John Davidson Beazley, professor of classical archæology, University of Oxford.

The University of Hull

At a meeting of the Privy Council on May 13, official notification was given that H.M. the Queen had approved of the granting of a charter constituting and founding the University of Hull. The University College of Hull was founded in 1927 by the Right Hon. T. R. Ferens and was opened to students on October 11, 1928. In 1952 there were 917 full-time and 68 part-time students, 108 postgraduate students taking the certificate in education and 21 engaged in research. The first chancellor of the new University will be the Right Hon. Lord Middleton, president of the present University College; and the first vice-chancellor will be Mr. J. H. Nicholson, principal of University College. Those students at Hull who are sitting for their final degree examinations this year will take those of the University of London; present first- and second-year students will be given the option of taking either the London or the Hull degree; all new entrants must take the Hull examinations.

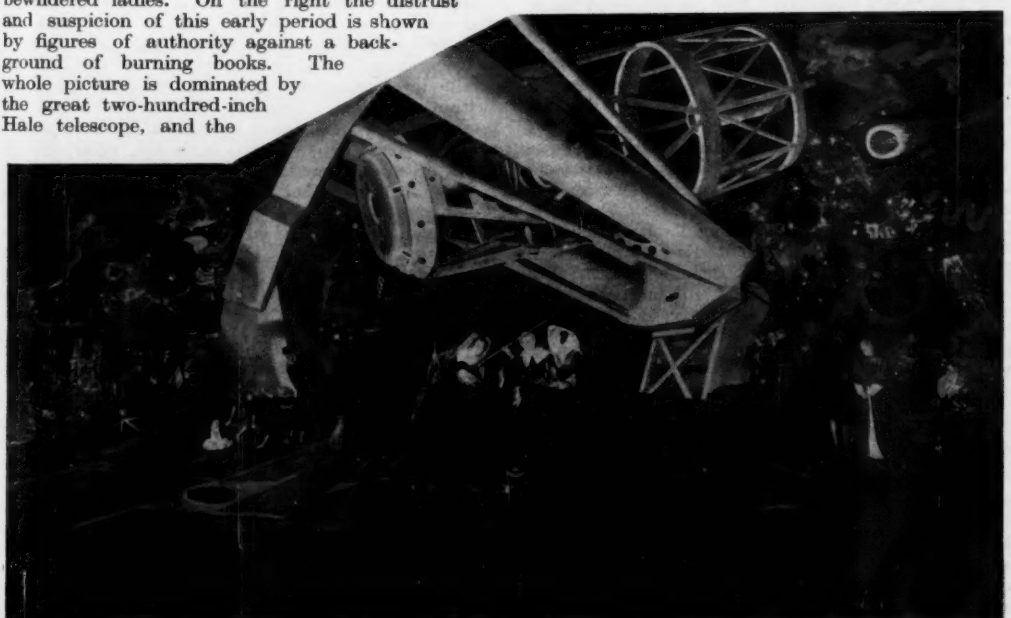
Gilbert White Memorial Fund Appeal

"The Wakes", Selborne, former home of Gilbert White, "father of English natural history", has recently come into the market. Colonel J. D. Bibby, the owner, has generously consented to give a number of residents in the area the first refusal of the property,

and the National Trust has agreed to accept it for permanent preservation, provided that the funds necessary for its purchase can be raised and sufficient endowment secured for its maintenance. The property consists of "The Wakes", 27 acres of parkland, and eight contemporary cottages which add much to the beauty of Selborne. The purchase price is £12,000. It is intended to restore the house, so far as is practicable, to its original condition. The National Trust has made an estimate of the amount of endowment necessary to keep the restored "Wakes" in good repair, and these items amount together to £12,500. An appeal has now been launched for a total of £24,500. It is proposed that "The Wakes" should then be occupied by a custodian appointed by the National Trust, and—together with its gardens and park—be open to the public. It would become a local centre of natural history, and a museum of the personal effects of Gilbert White and of the antiquities of Selborne. In this connexion it may be mentioned that Dr. W. S. Scott has offered his extensive collection of manuscripts and books connected with White, and no doubt more objects of interest would be forthcoming. Donations should be sent to the Treasurer, National Provincial Bank, Ltd., Alton, Hants.

Astronomy Mural in the Science Museum, London

Mr. A. R. Thomson, R.A., has completed a painting on astronomy to decorate a wall in the entrance hall of the Science Museum, London, near the well-known Foucault pendulum. Mr. Thomson was given *carte blanche* to depict the subject of 'Astronomy', and he has chosen as his main theme the invention and development of the telescope. On the left the small sons of Dutch spectacle-makers are playing with combinations of pairs of lenses, while sailing ships in port in the background indicate the development of peaceful trade. In the centre of the picture Galileo is using his telescope, ministered to by three rather bewildered ladies. On the right the distrust and suspicion of this early period is shown by figures of authority against a background of burning books. The whole picture is dominated by the great two-hundred-inch Hale telescope, and the sky behind is an animated representation of heavenly bodies among the figures of the constellations. The picture measures about 24 ft. by 15 ft., and its irregular shape was dictated by the shape of the wall to be filled.



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Oil Pollution of the Sea

At the invitation of the United Kingdom Government, an international conference on the prevention of oil pollution of the sea was held in London during April 26–May 12 and attended by delegations and observers from forty-two Governments. At the conclusion of the conference a convention was agreed, the main provision of which is the prohibition of discharge of oil and oily mixtures in certain agreed zones. The convention applies to all registered sea-going ships except those which are for the time being used as naval auxiliaries, those under 500 tons, and those used as whalers. (In a resolution, however, it was recommended that the principles of the convention should be applied so far as is reasonable and practicable to the ships to which the Convention does not apply.) Tankers are prohibited from discharging oil and oily mixtures within the specified zones as soon as the convention comes into force, but for other ships it is stipulated that discharge shall be made so far as practicable from land, and after three years they are prohibited from discharging within specified zones (which differ slightly in extent from those laid down for tankers). Twelve months after the convention comes into force, all ships will be required to be fitted with devices to prevent the escape of fuel oil or heavy diesel oil into bilges unless there is an oil separator on board through which bilges can be passed before discharge into the sea, and three years after the convention comes into force the contracting Governments shall ensure the provision of adequate facilities for the reception of oil and oily waters at the main ports. Provision is made for dealing with contraventions, amendments,

exchange of information, etc., and exceptions are made for special circumstances such as saving life at sea, damage to ships and so on.

The convention will come into force twelve months after the date on which no less than ten Governments have adhered, including five Governments each with not less than 500,000 gross tanker tonnage. In addition to the convention, the conference adopted eight resolutions which are submitted to the Governments and other bodies concerned for consideration and appropriate action, which included a recommendation that a further conference to review the matter in the light of experience of the working arrangements recommended by the conference should be held within three years.

The Mammal Society of the British Isles

The study of British mammals has undoubtedly been handicapped by the lack of a national scientific society devoted to the subject. At a conference held at the University of Birmingham during April 23–26, the appropriate organization, to be known as the Mammal Society of the British Isles, was brought into being, and the first officers and provisional committee were elected. In welcoming those present, S. Zuckerman emphasized the reciprocity of field and laboratory studies and stated that the Society would be of considerable value to experimentalists as well as to naturalists. This theme was developed in the opening paper by Alastair N. Worden on "The Study of Mammals", in which the need for codifying knowledge and the interest of mammalogy to those engaged in agriculture, forestry, conservation, pest control, veterinary science and human medicine were also discussed. It was suggested that a work devoted to mammals on the British list, comparable in status to the "Handbook of British Birds", although not necessarily modelled on similar lines, would fulfil an important gap and might be prepared on behalf of the Society as knowledge permitted. Other papers presented at the conference were on the trapping of small mammals (H. N. Southern), bats (M. Blackmore and J. H. D. Hooper), shrews (Peter Crowcroft), seals (R. M. Lockley), badgers (E. G. Neal and H. R. Hewer) and the work of the Merelewood Research Station, Nature Conservancy, by its director, K. R. S. Morris.

The following were elected officers of the Society: *President*, the Earl of Cranbrook; *Chairman*, A. N. Worden; *Hon. Secretary of the Scientific Advisory Committee*, H. N. Southern; *Hon. Treasurer*, H. G. Hurrell; *Hon. Secretary*, T. J. Pickvance, Department of Extra Mural Studies, University of Birmingham, Edmund Street, Birmingham, 3. The remaining members nominated to form the provisional committee were: K. R. S. Morris, H. V. Thompson, Peter Crowcroft, R. M. Lockley, M. Blackmore. The annual subscription has been fixed at one guinea, and further details can be obtained on application to the Hon. Secretary at the address given.

Vitamin Standards for Margarine

Acting on the advice of the Food Standards Committee, the Minister of Food, Major the Right Hon. Gwilym Lloyd-George, has made the Food Standards (Margarine) Order, which requires that Vitamins A and D shall continue to be added to all margarine sold by retail. The Order, which came into force on May 16, prescribes that margarine shall contain between 760 and 940 international units of vitamin A per ounce and between 80 and 100 international units of vitamin D per ounce. This vitamin A content is roughly equivalent to that of butter. The required vitamin D content remains the same (apart from a tolerance of 10 per cent) as under control. The Order prescribes the method of analysis to be used for determining the vitamin A content of margarine. In view of the difficulties involved in the estimation of vitamin D in margarine, it has been agreed with the manufacturers that they will add the vitamins in the form of a 'master mix'. A master mix should consist of an edible vegetable oil containing either vitamin A and vitamin D, or provitamin A and vitamin D. The manufacturers of vitamins in Britain have agreed to produce master mixes for this purpose containing vitamins A and D in the ratio of 940 : 100. Provided this ratio is observed, manufacturers are free to vary the composition of each master mix and the directions for its use according to the requirements of the margarine manufacturer. Any edible vegetable oil may be used as a diluent.

Energy Resources of Great Britain

In his presidential address delivered on April 8 to the Institute of Fuel, entitled "Energy for Britain—the Decades Ahead", Dr. Idris Jones has ventured a prophetic role in his comprehensive review of the trends in the development and use of fuel and energy from which the possibilities of the future may be envisaged. Coal is the primary source of energy in Great Britain; 25×10^9 tons have been mined up to now, and reserves of barely twice this amount still remain. Deposits of peat in the whole country are equivalent only to twenty years of coal production. For oil fuel, Britain will have to continue to rely on overseas supplies, and the duration of such supply may amount to another hundred years. The future production of thermal-electric power from coal may be generated at an efficiency of 37 per cent in large units of several hundred megawatts capacity. Complete electrification will be a feature of future coal-mining, which will be just as important in A.D. 2000 as it is to-day. Though the potentialities of generating hydro-electric power in Britain are small, interconnexion of power supplies between Britain and the Continent of Europe would be favourable. Of the other sources in Britain, wind-power is being investigated seriously, solar energy offers little at present, but heat pumps may do so. A new form of 'fuel' cell, using strontium-90, a fission product in an atomic pile, is now being developed, and nuclear energy should come to the rescue of disappearing coal reserves. Finally, a valuable detailed review is given by Dr. Jones of the probable future increases in fuel-burning efficiency during the next fifty years, whereby the current figure of about 35 per cent may increase to 45–50 per cent.

Bananas

For many years species of seemingly close affinity with the banana had all been classified within the genus *Musa*. For some of the species, however, the genus *Ensete* had been proposed in 1862. This received little recognition until E. E. Cheesman (*Kew Bull.*, No. 97; 1947) pointed out that its members differed from the true bananas in being mainly African in distribution, in being monocarpic, in having a basic chromosome number different from bananas, and in the large size of their seeds. The true bananas are generally held to be of Indo-Malaysian origin.

In a renewed investigation of the African species, R. E. D. Baker and N. W. Simmonds (*Kew Bull.*, No. 3, 405; 1953) reaffirm the validity of the genus *Ensete* and give a fully annotated conspectus of the species and also some interesting and important botanical, geographical and archæological information. *Ensete edule*, for example, was extensively cultivated for food in marshy lands in southern Egypt during a warm, wet climatic phase in Neolithic times and is portrayed on the pottery of the period. Because of its excellent fibre it may also have yielded the materials from which the royal linen was woven in later periods.

The inflorescence of the banana and some related genera is a very unusual and complex one and has been variously interpreted and described by different botanists. In a recent paper, in which the inception and development of the flower buds have been closely studied, A. Fahn (*Kew Bull.*, No. 3, 299; 1953) concludes that the inflorescence of *Musa* has probably passed through many more evolutionary changes than that in any of the related genera. In *Ravenala*, *Strelitzia* and *Heliconia* the flower clusters are arranged in cincinni. In relation to the facts now available, the view emerges that the flower groups in *Musa* have developed from cincinni and that the whole inflorescence—which becomes the banana bunch—consists of an axis, with spirally arranged bracts, in the axil of each of which a cincinnus is borne.

Chelsea Polytechnic

THE contribution made by leading technical institutions to the country's need for technologists and technicians is well shown by the statistics set out in the fifty-eighth annual report of Chelsea Polytechnic. In 1952–53 there were 775 full-time day students, 330 part-time day students and 1,729 evening students. Of these, no fewer than 848 were registered students of the University of London. Six students were successful in obtaining doctorate degrees, nineteen obtained their M.Sc.'s, while sixty-two obtained B.Sc. (special) degrees. The geographical distribution of the students at the Chelsea Polytechnic shows the remarkably wide area from which they are drawn. In addition to most English counties, full-time students come from Scotland (4), Wales (19), British overseas Dominions and Colonies (74), and various foreign countries (98).

French Fisheries Congress in Algiers

THE fifteenth French National Congress of Fisheries and Maritime Industries will be held in Algiers during June 21–27 under the auspices of the Society for the Professional and Technical Instruction in Maritime Fisheries in conjunction with the French Society for Economic Geography. Among the subjects to be discussed at the Congress will be scientific studies; legislation and economic studies; equipment; distribution of fish; by-products; preservation of fish (salting, smoking and drying); refrigeration; and culture of shell-fish. The bias of these studies will be towards problems specifically relating to French North Africa, but one session will deal with fish from other countries. Further information can be obtained from M. André Calandreau, 34 rue de Bassano, Paris 8e.

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: J. A. Austin (agricultural officer, Gambia), director of agriculture, Gambia; I. Sibson (senior agricultural officer, Gold Coast), assistant director of agriculture, Gold Coast; D. M. Montgomerie (assistant meteorologist, Nigeria), meteorologist, Nigeria; J. Dore, botanist (plant physiologist), Federation of Malaya; B. E. Mounter, plant breeder, Northern Rhodesia; I. A. Black, assistant conservator of forests, Nigeria; B. Brand, grassland ecologist, Department of Soil and Land Use Survey, Gold Coast; R. H. Eldridge, meteorologist, Gold Coast; Z. Horn, agricultural officer, Aden; A. R. Stobbs, soil survey officer, Gold Coast; P. J. P. Whitehead, biologist, Fisheries Research, Game Department, Kenya.

Beit Memorial Fellowships for Medical Research

THE Trustees of the Beit Memorial Fellowships for Medical Research in their report for 1953–54 announce the resignation from the Board of Prof. T. R. Elliott; he has been succeeded by Sir Alan Drury. Junior Fellowships (£630 a year) have been awarded as follows: R. G. Tucker, to investigate the action of divalent metals on the multiplication of bacteriophage, at the Sir William Dunn School of Pathology, University of Oxford; D. S. H. W. Nicol, to study the chemistry and pharmacology of peptide fractions of insulin, at the Dunn Institute of Biochemistry, University of Cambridge; and B. T. Donovan, to study the hypothalamic control of the secretions of anterior pituitary hormones, at the University of London Institute of Psychiatry, Maudsley Hospital, London.

Announcements

THE first award of the J. H. Andrew research fellowship in metallurgy in the University of Sheffield has been made to Mr. R. G. Ward, who is at present working as a research student in the Department of Metallurgy, University of Cambridge. The fellowship has been established by endowments from the English Steel Corporation, Ltd., Thomas Firth and John Brown Ltd., and Firth Vickers, Ltd.

THE title of professor of chemical pathology in the University of London has been conferred on Dr. F. T. G. Prunty in respect of his post at St. Thomas's Hospital Medical School, London; and that of reader in chemical biophysics in the University of London on Dr. R. A. Kekwick, in respect of his post at the Lister Institute of Preventive Medicine.

A SUMMER school in programme design for automatic digital computing machines, on the same lines as those of previous years, will be held in the University Mathematical Laboratory, Cambridge, during September 13–24. The course will give a basic training in the mathematical use of machines, dealing with the processes employed and their embodiment in programmes which specify the operation in detail, and lectures and practical classes will be held in the design of programmes for the Cambridge machine known as EDSAC. Application forms (to be returned by June 30) and further information can be obtained from G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge.

ERRATUM. In the Index of *Nature*, Vol. 172, p. xlv, for "Needham, Dr. James", read "Needham, Dr. Joseph".

DEVELOPMENT AND RESEARCH IN VACUUM TECHNIQUES

THE profound importance of high vacuum in research during the past decade or two is generally realized, but not, perhaps, the extent to which laboratory discoveries have led to important and increasing applications in industry since the Second World War. Without, for example, modern methods of pumping and leak detection for very large-scale projects, the utilization of atomic energy and all its implications would be impossible. W. Edwards and Co. have, almost since the inception of the company thirty-five years ago, specialized in vacuum techniques and therefore have been closely associated with its remarkable development, progressing during this time from a one-man business to the present organization consisting of some five hundred people.

At a luncheon held on March 5 to mark the opening of the Company's new factory at Crawley New Town, Sir Ben Lockspeiser, Secretary of the Department of Scientific and Industrial Research, referred to the vital necessity of research for the future of Britain, and said: "Not so long ago it was customary to speak of industry supporting science, but a research director of a famous American firm has rightly pointed out that, in these days, it is science which supports industry". After reviewing the important role of high vacuum, he pointed out that great industrial innovations now demand large sums for development and capital investment, which can only be met by large organizations; but, he said: "There is a vital and distinctive place for the specialist firm, which makes itself highly proficient in its own field and performs thereby an invaluable service for many industries, and often for research laboratories also. Messrs. W. Edwards and Co. is an excellent example of such a specialist firm, occupying a unique position and serving both industry in the newest technology and science in its most advanced technique".

Referring to the early days of the company, Sir Ben said: "In its great services to science, Messrs. W. Edwards and Co. is handsomely repaying an old debt, for I believe I am right in saying that about 1924 Dr. G. W. C. Kaye, who was head of the Physics Division of the National Physical Laboratory at the time, invented a new type of vacuum pump and approached Mr. Edwards, the present managing director of the Company, with a view to getting it manufactured. The Company began in this way by manufacturing Dr. Kaye's pump. The Company turned to the research laboratory for a good start in life, and it now makes a valuable contribution to keeping research alive".

Sir Ben urged that any research organization should include some people (there never could be very many) free to take long views and concern themselves with the fundamentals, so that the capital of scientific thought on a subject should not dry up—an event as serious as a failure of capital in finance—and concluded by saying: "The advance of science depends on new ideas, and your industry is —and always will be—in need of them. Cherish, therefore, the goose that lays the golden egg".

A tour of the new factory shows to what extent the firm has realized the value of research so stressed by Sir Ben, for a considerable floor area of the light and airy modern factory is devoted to research. The laboratories have been kept contiguous to one another, for work in one section greatly influences work in other sections. Thus workers on pumping problems have developed a gas-ballast rotary vacuum pump to deal with the contamination difficulties arising in the vacuum coating section, where the continuous coating of roll material has been developed, and in the freeze-drying section, where large volumes of water vapour must be handled. Vacuum metallurgy developments have also profited by allied problems arising in vacuum coating large areas, where significant quantities of metal must be evaporated. Not only is exploratory work undertaken to devise new and more efficient apparatus and keep the firm abreast of the latest developments, but also considerable investigation is carried out to develop plant and techniques to meet customers' applications—often work which may appear to have no connexion with high vacuum, for example, investigation into lacquers as an important complementary to the deposition of thin metallic films in vacuum.

No part of the floor area of the research sections is more than 20 ft. from a bus-bar system with plug-in fuse boxes for electricity, or from gas, cooling-water and compressed air supplies. Writing and discussion rooms are provided for each research section, as past experience of the firm has shown that the laboratory itself is not the most suitable place for the preparation of reports and reasoned discussion.

It is the firm's policy to encourage the use of its research staff in customer relations, and the Sales Department is organized accordingly. Not only is this important because of the new fields with which high vacuum is concerned, but also it keeps the sales organization closely informed of developments in the laboratory and at the same time maintains the interest of the research workers in the end-products of their work, stimulates their ideas and ensures a recognition of practicability.

The staffing of a research department in a new and specialized branch of applied science presents difficulties; taking a long-term view, research apprenticeships have been instituted. The apprentice serves the bulk of his time in the various sections of the laboratory, with training in the works and drawing office, and with one day each week to further formal education, for a period of five years. Training of research apprentices is not the only educational function of the firm's Research Department, as it is the focal point of experience for postgraduate students, who come from all over the world for summer vacation work.

The Company's reference library is of a very high standard in view of the importance which is attached to the abstraction and internal circulation of information on articles published throughout the world on high vacuum and allied subjects. This led to vacuum workers outside the firm appreciating the value of such a service, with frequent requests for copies of the abstracts, and in turn became the genesis of the periodical *Vacuum*, which was started four years ago as a journal, independent of the

parent Company, to publish abstracts, together with authoritative articles on its subject.

Mr. F. D. Edwards, replying to Sir Ben Lockspeiser, referred to the indebtedness of the Company, in its early days, when extensive advertising was quite beyond it, to the Physical Society's annual exhibition, where it was able to display its products to the scientific world through this unique medium. He went on to say that it is interesting to consider the many large organizations which have evolved from one-man enterprises established in the days of low taxation, when profits could be ploughed back to build up the firm's working capital. With modern taxation, it is virtually impossible for a young enterprise to grow without outside capital, and hence, he said: "Small enterprises will have to rely upon private funds for expansion, and therefore it is my hope that financiers and industrialists will take courage in both hands and be prepared to risk financial support to small enterprises until they reach such size that they can properly be handled by finance institutions. If some such action is not taken, many promising ideas will perish from lack of funds and possible world markets be lost to Britain".

ERGONOMICS RESEARCH SOCIETY

FOURTH ANNUAL CONFERENCE

THE fourth annual conference of the Ergonomics Research Society was held during April 5–7 at Ashorne Hill, near Leamington. Following the precedent of earlier years, the papers were planned around one main theme, on this occasion "The Scientific Study of Human Work in Industry". Sir George Barnett, H.M. Chief Inspector of Factories, opened the conference, reminding his hearers that the administration of the Factories Acts brings him and his staff into daily contact with the matters covered by this new term 'ergonomics'. Quite apart from hazards of accident and industrial disease, the Acts deal with heating, ventilation, lighting and seating; inspectors are constantly reminded of the physiological and psychological importance of these, and of the need for further progress in such directions as the design of machinery. He suggested that one of the main problems of the future would be the adaptation of methods of work to a population including an increasing number of older people, and, very reasonably, he pointed out that research results on this or any other problem are more likely to be used if reported in terms comprehensible to the interested layman.

The first paper, given by O. G. Edholm, was a contribution to understanding by the layman of physiological methods of measuring work. Admitting the impossibility of a complete exposition, Dr. Edholm nevertheless outlined the various effects of activity on the human body in a way which made subsequent papers far more useful to the non-physiologist. He dealt with metabolism at rest and at work, giving in round figures the amounts of heat involved; his comparisons of oxygen usage were illustrated by demonstration, the subject at first sitting, and then stepping up and down. The limits of activity as set by heat loss, or cardiac capacity, or by other reasons were discussed, and the distinction was drawn between fatigue due to posture and that due to work in the mechanical sense of foot–pounds expended.

Two papers dealt with the physiological stress of heavy work in hot surroundings, the first by J. S. Weiner and A. R. Lind, and the second by H. S. Belding and T. F. Hatch. Both were primarily concerned with the same problem—that of setting limits to environmental conditions which, while expressed in physical terms readily measurable by engineers, would safeguard the human being working in them. Weiner and Lind discussed the various permissible limits that had been proposed in coal mining, in particular examining the discrepancy between the figures put forward by Linsel in Germany in 1949 and those deduced from a variety of other sources, which, while agreeing among themselves, suggest that Linsel's limit is somewhat low. The second paper (which was read by Prof. Belding alone) accepted the challenge to set physiological limits in a simple and easily measured way; in extremely hot jobs in the glass and metal industries, it has been found practically effective to calculate the total heat input and to balance this against sweat-rate. Input was calculable from radiant temperature, air temperature and movement, and metabolism estimated from the work done; a maximum sweat-rate of 1 l./hr. for a spell of 6–8 hr. for "very fit, acclimatized men" was postulated. In hot and moist conditions, the limit would be the rate of evaporation rather than the rate of sweating. Both these papers dealt with working conditions far above the accepted range of comfort; the paper by D. E. Hickish on the thermal comfort of workers in light industries in summer dealt not merely with physical and physiological data, but also with the subjects' views expressed on a rating scale. Discussion of the physiological limits suggested that work should preferably be well within them; mention of accident-rates in mining illustrated this, with the question "At what point does the man become irritable and liable to be careless?". The psychologists have much work ahead of them in such problems.

As R. Harper put it, his paper on the study of craftsmanship in dairying was concerned with the cross-links between the physical problem of measuring the properties of deformable material and the psychological problems of describing and codifying the experiences gained from handling it. The particular material described was cheese; but apparently similar problems exist in connexion with wool and other substances of natural origin. Cheese graders have long used tests such as pressing with the thumb to assess the condition of cheese; the obvious course of tasting is rarely resorted to, since no palate could stand up to the large number of cheeses. The research was not concerned merely with relating subjective judgments to instrument readings; a major difficulty was that of relating either of these to the ultimate criterion of the goodness of the cheese.

Sven Forssman described a study of workers in underground factories in Sweden which demonstrated the effect of psychological factors very clearly. Workers in three underground factories had complained of fatigue, eye-strain and the like; in the study they were compared with a similar population working above ground. There appeared to be little difference from a medical point of view between the two groups, and only in some places were conditions of lighting worse for the underground workers. But it was concluded that, other things being equal, the psychological climate among the underground workers was more sensitive, and any shortcomings in human

relations were more readily noticed, leading to absence and symptoms of sickness.

J. E. Karlin presented a paper on telephone research, concerning the habits and complaints of telephone users and their reaction to innovations. In this field such small matters as an instrument a little heavier or lighter than usual may affect the user, and investigation of his likely reaction is attempted before large-scale changes are put in hand. Questionnaires of the 'feed-back' type have been used, but it was stated that obtaining the user's opinion alone is insufficient; observation of his behaviour is also needed. In telephone work this is made easier by the fact that most users regard everything other than the actual receiver and transmitter as a 'black box', and in this region the observer has considerable freedom to make changes. Experiments on abbreviation, by which each partner in a conversation hears only part of the other's speech yet understands what is being said, threw an interesting light on how much we really listen. In trying out new equipment, the user has to be given a fairly long period of test; immediate opinions may be reversed later.

Three papers, by R. Conrad, H. G. Maule and D. Cox, found common ground when considering the position of industrial psychology. Conrad commented on the steadily decreasing number of Industrial Health Research Board reports over a period of years, a decrease which is concurrent with the growth of the techniques of work-study practised in industry. He suggested that a return to more rigid experimental methods would benefit the psychologist in industry, and also more contact between fundamental theory and applied work. Problems in the Armed Forces have given psychologists urgent *ad hoc* questions to solve, and have diverted their attention from basic matters. In the discussion, it was suggested that industry is more interested in immediate problems; the psychologist's is a double task, to provide solutions to these and at the same time to anticipate future demands before industry is aware of them. In reminding the conference of some early work he had done on improving work-methods in laundries, Maule emphasized the point that methods are important not only as a means of getting more work done, but also in affecting the attitude of those who do it. Bad methods cause as much waste through irritation as through sheer physical loss of time and energy, he suggested, and for this reason are often resented by the worker on the job before managers are even aware of them. Arising from this the point was made in discussion that managers often try to limit the application of work-study in the interests of 'flexibility'—a euphemism, it was suggested, for 'room for manœuvre for bad management'. Whatever the techniques of work-study, its proper application depends on the attitude of management. Cox's paper dealt with the way in which work-study as a technique has been used in industry in too mechanistic a fashion. Findings on the effects of monotony, from as far as twenty-five years back, have suggested that it can reduce output, yet work is often still organized in ways which fail to cut monotony to a minimum. There is need for more exchange between those who carry out work-study in industry and those doing research, both in providing facilities for research and in making use of results.

Sir Frederic Bartlett, in the closing address to the conference, ranged over many topics suggested by the papers. He compared the classic physiological methods of measuring work with the less exact psychological measures, reflecting that as work is increasingly mechanized the former, dealing with gross energy outputs, will be less in demand. In physically light work involving skill or dexterity, time-and-motion study goes so far, but fails at the point where perceptual skills become important; this is a field in which research has immense possibilities. In training, too, a new approach is needed: the concept of training for a specific job is inadequate in an age where technical advances alter jobs so frequently; what is needed is training which will allow rapid adaptation to change. Adaptation to change, Sir Frederic observed, also brings one to questions of human relations; this remark, coming from so eminent a member, encourages the hope that the Ergonomics Research Society may be spurred on to regard the study of the working environment in a wide sense.

RESEARCH FILM

BULLETIN OF THE RESEARCH FILM COMMITTEE OF THE INTERNATIONAL SCIENTIFIC FILM ASSOCIATION

ALTHOUGH cinematography is increasingly used for research, those workers for whom cinematography is a prime and essential instrument remain relatively few and scattered. The bulletin of the Research Film Committee of the International Scientific Film Association should therefore fulfil a useful purpose. Called *Research Film*, it is edited by Dr. G. Wolf, director of the Göttingen Institut für Film und Bild, and by M. Jean Dragesco. Its contents are variously in English, French and German, while some of the editorial matter is in all three languages.

In the second of the three issues* published up to December 1953, Anthony R. Michaelis reviews the literature of the research film. He notes that, while there are several thousand journal articles on scientific cinematography, there are few books. He descriptively lists some of these books, and gives the results of his survey of journal publications. His figures and graphs show that scientific cinematography dates back to the beginning of cinematography, and that it has been used to a varying extent in a number of countries. There would appear, however, to have been a marked increase in its use since about 1930. In biological cinematography Germany takes a leading place, in medicine Germany and the United States, and in engineering the United States; but Dr. Michaelis's survey is not exhaustive and does not, for example, include Russian literature.

Much the greatest part of this international journal's matter consists of short articles, often illustrated, on apparatus and methods. H. E. Edgerton describes the 1-μsec. rapatronic camera; S. W. Bowler, single-picture control devices; D. Rebikoff, underwater cinematography; and W. Bohme and J. Nauta, roentgen-cinematography. There are articles by J. Frederic, J. Dragesco, A. J. Pijper and others, and lists of the writings of the scientific cinematographers J. Comandon and Lucien Georges Bull.

C. Denis Pegge

* *Research Film. Le Film de Recherche. Forschungsfilm.* No. 1, pp. 28; No. 2, pp. 40; No. 3, pp. 34. (Dr. G. Wolf, Institut für den Wissenschaftlichen Film, Göttingen.)

THE ESSO REFINERY, FAWLEY

At the beginning of July 1949 a site of 450 acres near the village of Fawley, Hampshire, was still covered with rolling wood and farmland. In November 1951, less than two and a half years later, a vast level plain had replaced the farms and from it rose the spectacular towers of the new £37,500,000 oil refinery built for the Esso Petroleum Company. By that date 97·48 per cent of the work on the new refinery had been completed. Most of the major process units had been in operation since July 1951, yet the original date set for the completion of this undertaking, the largest oil refinery ever built at any one time anywhere in the world, had been January 1952. This was a tremendous achievement from many points of view—technical, financial, economic and social.

The refinery was built by a combination of American management and British labour. The Productivity and Technical Assistance Division of the Mutual Security Agency Mission to the United Kingdom wished to determine the nature of the management policies and practices responsible for the unusually rapid construction of the refinery. A report, prepared by A. D. Gray and Mark Abrams, of Research Services, Ltd., aroused such wide interest that it has now been made available to the British Institute of Management for general publication.

The investigators were asked to discover how far and in what ways management organization and policy and labour–management relations had contributed to the unexpectedly high productivity of the men on the job. The report shows that the factors which enabled the construction of the refinery to be completed well ahead of the date originally scheduled include both fortuitous external circumstances and particular techniques of organization and management employed by those responsible for the job. The main favourable external circumstances were: (1) dollars were available for the purchase of materials and equipment in the United States; (2) at the time that initial orders were placed, materials were readily available in the United States; (3) the size and importance of the refinery were exceptional and this helped to create a favourable psychological atmosphere. Moreover, a man of outstanding ability had been chosen as the project manager, capital equipment was on a generous scale, suppliers made extra efforts to supply materials both from realization of the refinery's importance and in anticipation of future orders, and workers took pride in working on the project; (4) because of its special dollar-saving importance to the British economy, the job had the support of the British Government, which assisted in obtaining priorities for materials purchased in Great Britain.

Not all the circumstances were favourable, however. There was, for example, a shortage of skilled labour both in the area and in the country as a whole; the site was far removed from populated areas; there was a virtual absence of normal transport facilities; and working conditions on the site proved particularly difficult. Yet the task was completed before the agreed time.

The observers made a special study of the specific managerial and organizational practices which contributed to the speedy construction of the refinery. These were reported as follows. There was, first, close co-operation between contractor and client. The Esso Petroleum Co. had senior representatives always on the site, both to inspect the work and for immediate consultation on matters on which the approval of the client was required.

Secondly, detailed plans were prepared at an early stage. All the ordering of materials was done from these plans. The technical resources of Esso's affiliated company, Standard Oil Development, and particularly its extensive records and experience of the construction of refineries, were drawn upon in estimating supply and labour needs.

Thirdly, materials were ordered early.

There was, in addition, a vigorous scheme for expediting deliveries, as well as a system of coding orders, deliveries and allocation of all materials according to the units where they were required, so that both the supply and cost situation for any unit could be quickly ascertained. A monthly report showed the actual and scheduled progress and there was continuous inspection of the site by top management. A system of communications was developed to ensure that all in authority were informed of everything that affected the whole job. Most important, engagement of all labour was under one contract drawn up with the Confederation of Shipbuilding and Engineering Unions. This resulted in a unified system of wages for all crafts. A system of supervision was organized which made it the primary responsibility of supervisors to see that work was not interrupted through lack of materials, labour or skill; special measures were taken to reduce absenteeism.

A valuable means of eliminating difficulties was the formation of a site executive committee of shop stewards and management representatives to settle problems about working conditions on the site. The management was adamant in refusing to allow labour disputes to be discussed except through official trade union channels; this led to a considerable strengthening of the 'powers' of shop stewards. One contractor was made responsible for the major part of the work and the number of sub-contractors was reduced to a minimum. This simplified the problems of co-ordination and made possible a streamlined system for the control of progress and supplies; it also facilitated the most effective and economical use of labour, and greatly assisted trade union–management negotiations. T. H. Hawkins

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PROBABLE OBSERVATION OF THE GALACTIC NUCLEUS AT 400 Mc./s.

By R. X. McGEE and J. G. BOLTON

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We have recently made a survey of the central section of the Milky Way using a pencil-beam aerial at a frequency of 400 Mc./s. The survey covered the zone of the celestial sphere from − 17° to − 49° in declination and approximately 15 hr. to 20 hr. in right ascension. The aerial reflector, a paraboloid of revolution of aperture diameter 80 ft. and focal length 40 ft., is hollowed out of the earth; its surface is consolidated with concrete and covered with half-inch mesh wire-netting. The feed consists of a wide-band dipole and plane reflector supported on an aluminium mast. The aerial beam-width is 2° between half-power points at 400 Mc./s., and the beam can be directed by tilting the mast in the meridian plane. The relation between the angle of

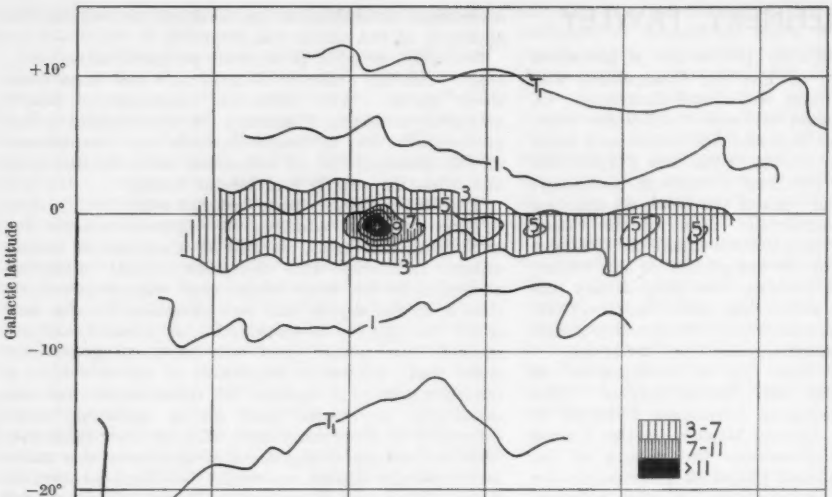

Fig. 1. Contours of equivalent aerial temperature at 400 Mc./s. plotted in galactic co-ordinates. The numbers on the contours give the increase (in units of 30° K.) above the temperature measured along the contour T_1. This temperature is approximately 55° K.

tilt of the mast and the zenith angle of the direction of maximum sensitivity of the aerial beam was determined by observations of the sun at about the summer solstice and of the intense radio star Centaurus-*A*. These observations also determined the collimation plane of the aerial. Centaurus-*A* was used as a convenient daily reference for calibrating the overall sensitivity of the aerial and receiver. The reflector has about the same ratio of focal length to aperture as the 218-ft. paraboloid at Jodrell Bank which Hanbury Brown and Hazard have used with a 2° beam at 158 Mc./s. to survey part of the northern sky.

Records were taken at intervals of 0·5° in declination between declinations − 23° and − 30° and at intervals of 1° outside this range. For each declination two or more records were taken and the readings averaged. The results of the observations are displayed in Fig. 1 as contours of equivalent aerial temperature plotted in galactic co-ordinates. The celestial co-ordinates of the 1953 observations were corrected for precession to epoch 1900 and converted to galactic co-ordinates by means of the Lund Tables. The numbers on the contours in Fig. 1 give increases (in units of 30° K.) above the temperature measured along the contour marked T_1. This temperature is 40° K. above the minimum measured in the low-temperature region near the south galactic pole. An accurate determination of this base temperature is very difficult: the preliminary value suggested by our observations is 15° ± 10° K. The noise-fluctuation level represented on the average 3° K.

It will be seen that there is a strong concentration of brightness towards the line of galactic latitude $b = -1°$; in general, the profiles along lines of galactic longitude are about 5° between half-power points. Along this central 'bright streak' are a number of maxima with one outstanding maximum centred at $l = 327·9°$, $b = -1·0°$. The uncertainties in this position are estimated at ± 0·2° in each co-ordinate. Profiles in galactic latitude and longitude through this point of maximum temperature (436° K.) are reproduced in Fig. 2, together with the aerial power diagram. The interpretation is complicated by the rapid variation of the background in this vicinity. We consider that both profiles and contours indicate a very intense source (contributing a component of aerial temperature of about 150° K.) superimposed on a background of Milky Way radiation. The shaded areas on the profiles represent the suggested contribution from this source. Were it a point source, the flux density of 400 Mc./s. radiation would be $1·4 \times 10^{-23}$ watts per square metre per cycle per second. This is of the same order as the flux from Cygnus-*A* at this frequency obtained by Stanley and Slee (unpublished data). The angular extent of the object appears to be less than the beam-width, 2°, and since the aerial has such high directivity the position of its centroid cannot be far from the indicated maximum of the brightness contours, but it may possibly be slightly to the north.

The position of this source is close to the accepted direction of the galactic centre, although this direction

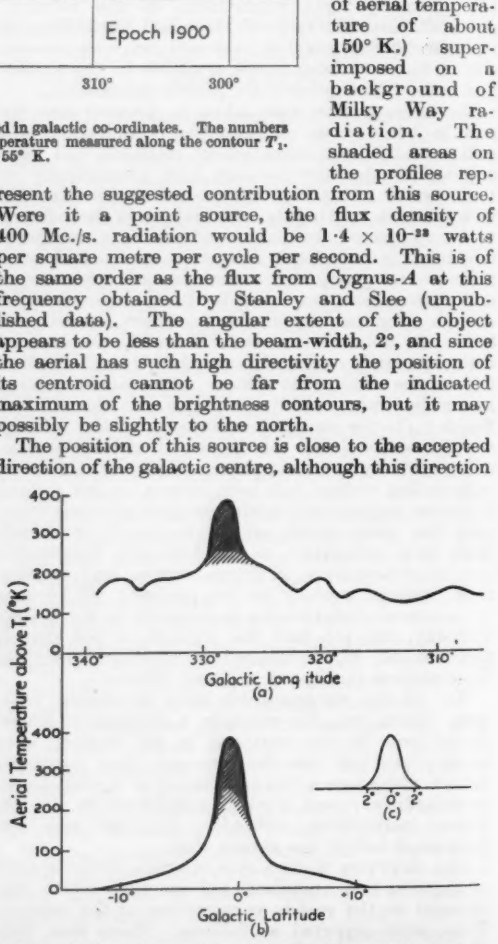

Fig. 2. Profiles of equivalent aerial temperature at 400 Mc./s. (*a*) Along galactic latitude $b = -1·0°$. (*b*) Along galactic longitude $l = 327·9°$. The shaded areas indicate the suggested contribution of the central source. (*c*) Aerial power diagram

is not known very accurately. In optical observations the central region is heavily obscured—in places the obscuration amounts to more than 8 magnitudes. Even observations in the infra-red have been unable to penetrate all the dark clouds. Earlier estimates of the position of the galactic centre, obtained from radio data, have been derived mainly from observations with wide-beam aerials. Although absorption of radiation at frequencies of 100 Mc./s. and above should be small, the poor resolving power of these aerials does not permit very accurate determinations of position. The most probable position of the galactic centre derived from both optical and the earlier radio data is $l = 328°$, $b = -2°$, with a spread of a few degrees in each co-ordinate about this value.

Sources near the centre of the galaxy have been observed, using the pencil-beam technique, by Piddington and Minnett[1] at 1,210 Mc./s. (2·8° beam) and by Bolton *et al.*[2] at 150 Mc./s. (6° beam). These observations probably refer to the same object as observed at 400 Mc./s. Similarly, interferometer observations at about 100 Mc./s.[2–4], although confused by the presence of several sources in the primary aerial beam at the same time, have also indicated a strong source in this vicinity. The angular size at 100 Mc./s. appears to lie between $\frac{1}{2}°$ and $1°$ [2,4].

The present survey gives the most accurate position of this object, and the close correspondence with the expected position of the galactic centre suggests the probability that it may, in fact, be the galactic nucleus. However, the apparent angular size of the source at 100 Mc./s. is considerably larger than the 3′ of arc expected for the galactic nucleus in the visible region, if it were comparable to that of the Andromeda nebula (Baade, personal communication). However, the size may differ at the higher frequencies, and further study of the fine detail of the brightness distribution in this region is necessary.

We wish to thank Dr. K. C. Westfold, of the University of Sydney, and Messrs. G. J. Stanley and O. B. Slee, of this Laboratory, for their participation in the construction of the aerial and other aspects of the work. The project was originally suggested to one of us by Dr. W. Baade.

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INFLUENCE OF DISSOLVED GASES ON HYDROGEN PEROXIDE FORMATION AND BACTERIOPHAGE INACTIVATION BY RADIATION

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THE behaviour of the free radicals formed during the irradiation of water has been investigated by studying (*a*) the formation of hydrogen peroxide, and (*b*) the inactivation, during short-time irradiation, of bacteriophage in very dilute suspension. We call the latter 'immediate' inactivation of the phage, as distinct from inactivation arising from delayed effects of the radiation. Information has thus been obtained about radical interactions to form hydrogen peroxide; and radical reaction with an added 'solute', which in the case of bacteriophage is the simplest living entity on which radiation effects can be studied. We regard these systems as being to some extent complementary, since the formation of hydrogen peroxide involves the strongly oxidizing HO_2 radical, whereas bacteriophage is not affected by oxidizing radicals[1,2] but is inactivated by reaction with reducing radicals, the nature of which will be discussed below. Conditions which favour the production of hydrogen peroxide are those in which immediate phage inactivation is minimal, and vice versa.

Hydrogen Peroxide

Triply distilled water was exposed to an electron beam of 1-MeV. electrons from a Van de Graaff generator, and the formation of hydrogen peroxide followed by the method of Eisenberg[3]. The desired gas or gas mixture was bubbled through the water for 8 min. before irradiation commenced, and during the exposure. This ensured equilibration and the removal of gases which might be formed by the action of the radiation. The techniques for bubbling and irradiating have been previously described[4].

In Table 1 are set out the results of hydrogen peroxide determinations in water which had been irradiated in the presence of various dissolved gases. In each case hydrogen peroxide determinations were made after irradiations at three different dose-levels. It can be seen from the table that, at all doses used, the maximum hydrogen peroxide concentrations obtained with mixtures of hydrogen and oxygen were roughly double the concentrations with 100 per cent oxygen. The results are presented graphically in

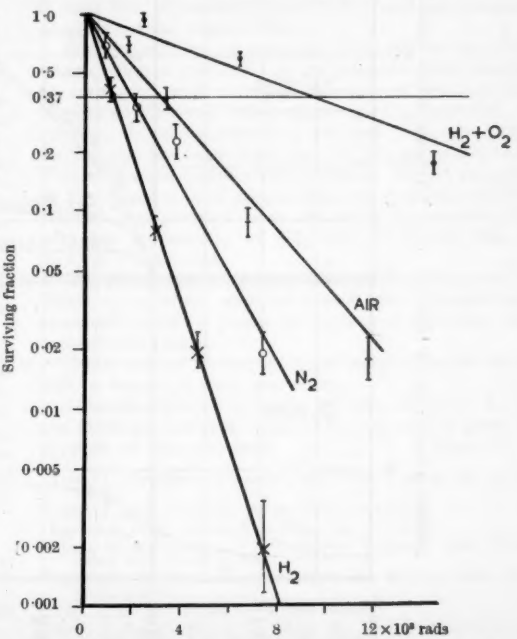

Fig. 1. Survival curves for *S*13, with various gas treatments

Table 1

Gas mixture	Hydrogen peroxide, in μmoles/litre, produced by dose† of: $2{\cdot}9\times10^4$ rads	$10{\cdot}5\times10^4$ rads	115×10^4 rads	Inactivation dose‡ rads
100% O_2	47	123	472	4,600±450
21% O_2+79% N_2	47	106	155	3,700±350
95% O_2+ 5% H_2*	—	—	—	4,200
84% O_2+16% H_2*	66	187	698	—
66% O_2+34% H_2*	72	242	787	—
50% O_2+50% H_2	—	—	—	11,600±450
38% O_2+62% H_2*	78	258	767	—
5% O_2+95% H_2*	67	158	318	11,000
1% O_2+99% H_2	—	—	—	9,500
100% H_2	0	0	0	1,150± 70
50% H_2+50% N_2	0	0	0	1,000
100% N_2	0	0	0	2,150±230

* Percentages are approximate, as there were slight variations within experiments at different radiation doses.

† Doses for experiments with the electron beam are based on chemical dosimetry, with assumed value for $G_{Fe} = 20$. There were variations of ± 5 per cent from the nominal doses stated at the head of each column.

‡ Where no standard error is given, result quoted is for one experiment which formed part of a set in which survival curves with different gas treatments were compared.

Fig. 2*A*, which also shows some results not included in Table 1.

Inactivation of Bacteriophage

Techniques for investigating the inactivation of bacteriophage during irradiation have been previously described[1]. The desired gas solutions were obtained by methods similar to those used in the hydrogen peroxide experiments. At high dose-rates, survival curves were of exponential form, for both electron and X-irradiation. Where survival is of this type, the number of particles, dn, inactivated by a small dose, dR, is proportional to the number of active particles. Thus:

$$-\frac{dn}{n} = \frac{1}{D}\,dR, \qquad (1)$$

$1/D$ being a constant of proportionality. The integral form of this equation may be written

$$n/n_0 = \exp - R/D, \qquad (2)$$

and D, the 'inactivation dose', is that dose which will reduce the active fraction to e^{-1} (37 per cent) of the number of phage particles originally present. If equation (1) is re-written

$$-dn/dR = n/D, \qquad (3)$$

it can be seen that the number of phage particles inactivated per unit of dose (that is, the 'yield') is proportional to the reciprocal of the inactivation dose.

Fig. 1 shows survival curves from a typical experiment, in which four different gas treatments were applied to dilute suspensions of bacteriophage *S*13.

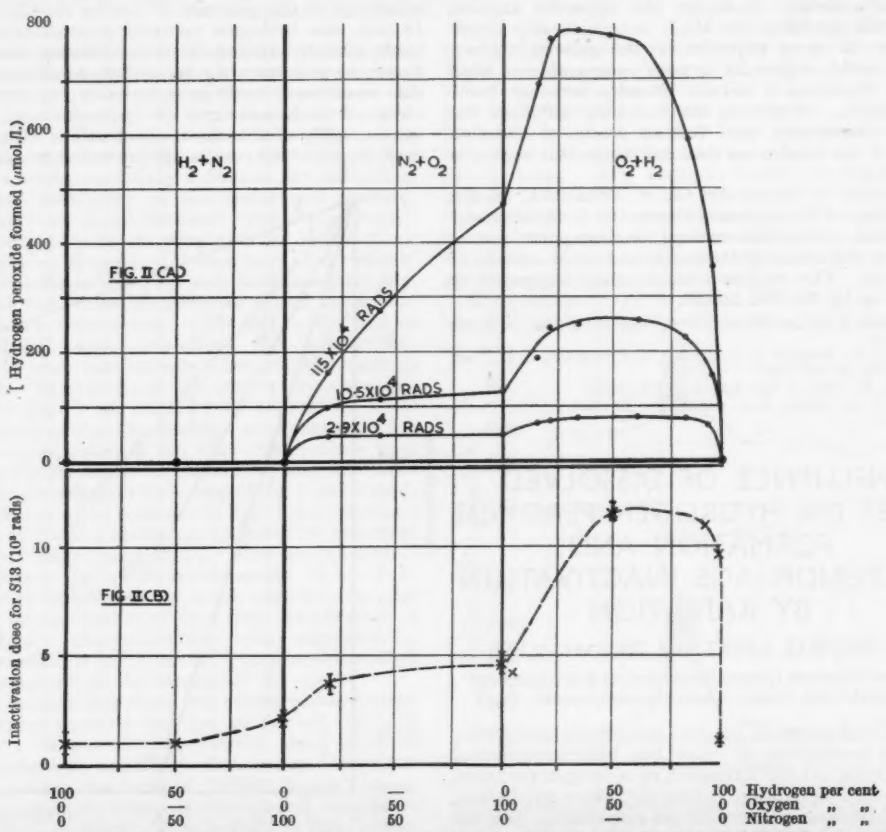

Fig. 2. Effect of gas treatment on (*A*) hydrogen peroxide yield; (*B*) inactivation dose for bacteriophage *S*13

Table 2

Gas present	Reactions of H	Reactions of OH	Relative yield of inactivated phage: Expected	Relative yield of inactivated phage: Observed	Relative yield of hydrogen peroxide: Expected	Relative yield of hydrogen peroxide: Observed
N_2	$H + \Phi \rightarrow H\Phi$	? $OH + OH \rightarrow H_2O_2$ (low probability)	1	1	Small	0
H_2	$H + \Phi \rightarrow H\Phi$	$OH + H_2 \rightarrow H + H_2O$ $H + \Phi \rightarrow H\Phi$	2	1·84 ± 0·13	0	0
O_2	$H + O_2 \rightarrow HO_2$ $HO_2 + HO_2 \rightarrow H_2O_2 + O_2$ or $HO_2 + H \rightarrow H_2O_2$ or $HO_2 \rightleftarrows H^+ + O_2^-$ $O_2^- + H^+ + \Phi \rightarrow H\Phi + O_2$	As with N_2	< 1	0·49 ± 0·05	1	1
$O_2 + H_2$	$H + O_2 \rightarrow HO_2$ $HO_2 + HO_2 \rightarrow H_2O_2 + O_2$ or $HO_2 + H \rightarrow H_2O_2$ or $HO_2 \rightleftarrows H^+ + O_2^-$ $O_2^- + H^+ + \Phi \rightarrow H\Phi + O_2$	$OH + H_2 \rightarrow H + H_2O$ $H + HO_2 \rightarrow H_2O_2$ or $H + O_2 \rightarrow HO_2$ and reactions proceed as in left-hand column or $H + \Phi \rightarrow H\Phi$	≪ 1	0·18 ± 0·02	2	Approximately 2

The inactivation doses were 1,200, 2,100, 3,200 and 10,000 rads respectively (1 rad is defined as energy absorption of 100 ergs/gm.: International Commission on Radiological Units, 1953) for irradiations in the presence of hydrogen, nitrogen, air, and oxygen plus hydrogen. The corresponding yields were in the ratio 1·75, 1, 0·65 and 0·21. Results of experiments on various batches of *S*13, with X-rays at different dose-rates, and with electrons, have been pooled to give mean inactivation doses for each gas treatment. These are presented in Table 1, whence it can be seen that the radiation was most effective with hydrogen bubbling, with which no hydrogen peroxide was detected, and least effective with hydrogen and oxygen mixtures, with which hydrogen peroxide production was maximal.

The results are presented graphically in Fig. 2*B*. The variation of inactivation dose with gas treatment can be seen to follow the same trend as the yield of hydrogen peroxide.

Discussion

Most biological effects which can be ascribed to the action of radicals appear to occur through oxidations[4–7]. It is of considerable interest, therefore, that bacteriophage should show in such a clear-cut way a far greater sensitivity to reducing than to oxidizing radicals. Previous results pointing to this fact[1,2] have been fully confirmed by the results of irradiations in hydrogen, and in hydrogen and oxygen mixtures. It is probably relevant that, according to data given by Daniels, Scholes and Weiss[8], the immediate *in vitro* effect of radiation on the viscosity of animal deoxyribose nucleic acid is twice as great *in vacuo* as in the presence of oxygen.

The reactions bringing about the formation of hydrogen peroxide, and the reducing mechanisms which cause inactivation of the phage, can be described by the following simple theory of radical formation, which we have based on the assumption that, when water molecules decompose under the action of radiation, the first reactive radicals formed are H and OH. These may be transformed by collision with molecules of dissolved gas, as follows:

Oxygen present $H + O_2 \rightarrow HO_2$ (4)

$HO_2 \rightleftarrows H^+ + O_2^-$ (5)

Hydrogen present $OH + H_2 \rightarrow H + H_2O$ (6)

Thus hydrogen peroxide may be formed via:

$$HO_2 + HO_2 \rightarrow H_2O_2 + O_2 \quad (7)$$

$$HO_2 + H \rightarrow H_2O_2 \quad (8)$$

Reactions (7) and (8) both require the presence of oxygen. The addition of hydrogen greatly increases the probability of (8). With no oxygen present, for example, with nitrogen bubbling, the reaction

$$OH + OH \rightarrow H_2O_2 \quad (9)$$

may take place, but the probability appears to be very low.

The reducing mechanisms by which phage is inactivated are not known, but may be presented formally as follows:

$$H + \Phi \rightarrow H\Phi \quad (10)$$

$$O_2^- + H^+ + \Phi \rightarrow H\Phi + O_2 \quad (11)$$

Φ and $H\Phi$ representing an active and an inactive phage particle respectively.

The probability of reaction (10) will be doubled, when phage is irradiated in the presence of hydrogen, as compared with nitrogen, because of reaction (6). Reaction (11) will take place in the presence of oxygen, following reactions (4) and (5); the probability will be lower than that of (10), since reactions (7) and (8) will remove HO_2 radicals. In the presence of hydrogen as well as oxygen, the removal of HO_2 radicals will proceed more efficiently by reaction (8), and the probability of (11) will be lower than if hydrogen is absent.

The theory here set out has been summarized in Table 2, in which also are stated the expected and observed relative yields of hydrogen peroxide and inactivated phage.

These results form part of a body of work which will be reported fully elsewhere.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Transfer of Internal Energy in Molecular Collisions of Flexible Hydrocarbons

A well-known problem in the physical chemistry of aliphatic hydrocarbons is to account for the marked dependence of reactivity on molecular structure, especially for reactions in the gas phase. For example, in oxidation of isomeric paraffins below about 300°, reactivity is greatest for the least-branched chain. Among the normal paraffins, the reactivity of homologues increases as the chain-length increases[1]. Various explanations of this influence of molecular structure on chemical reactivity have been suggested. Marked polar influences or valency drifts of electrons are not likely to be significant in this class of molecules. Molecular structure is, however, likely to have a marked effect on the degree of coupling between vibrations in different parts of the molecule[2] and also on the degree of flexibility of the hydrocarbon[3].

Gas kinetic studies have shown[4] that even normal paraffins are extensively crumpled at ordinary temperatures, as a result of rotations about C—C single bonds. Molecular flexibility seems to be an important factor in facilitating transfer of internal energy in gaseous collisions. In mass diffusion, flexible hydrocarbons show "hydrogen-effects"[5], and there is an enhanced transfer of internal energy on collision with molecular hydrogen. Again, from ultrasonic measurements on mixtures of ethylene with other gases[6], paraffin hydrocarbons prove to be very efficient in transferring vibrational energy to the ethylene. These observations have been ascribed to "wrestling collisions" arising from the flexibility of these molecules.

We have now found a striking effect of molecular flexibility in the collision efficiency of hydrocarbons of the C_5 and C_6 groups, for transferring vibrational energy to ethylene. As the hydrocarbon molecule becomes stiffer, a marked increase is required in the number Z_{eff} of collisions with an ethylene molecule before the transfer of a quantum of vibrational energy $0 \rightarrow 1$ will take place to the ethylene.

At 298° K. the values of Z_{eff} are found to be approximately :

Hydrocarbon	*n*-pentane	*iso*-pentane	*neo*-pentane	ethylene (self-collisions)	*cyclo*-pentane
Z_{eff}	50	60	120	2,500	3,300

Hydrocarbon	*n*-hexane	*iso*hexane	*cyclo*hexane
Z_{eff}	30	40	100

The marked contrast in collision efficiencies between *cyclo*pentane and *cyclo*hexane accords with previous suggestions about wrestling collisions. These are much more likely to blur vibrational quantum levels and thus to facilitate the transfer translational → internal energy when a flexible molecule is one of the collision partners. It is noteworthy that collisions with the stiff *cyclo*pentane molecule are even less efficient for promoting vibrational energy transfer than self-collisions between two ethylene molecules.

Since chemical reactions of the paraffins in the gas phase show evidence of involving the 'chain transfer' of energy[7], it becomes understandable that factors such as molecular flexibility which control energy transfer can also control relative reactivity, in the absence of more powerful influences.

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March 1.

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A Two-Crystal Gamma-Ray Scintillation Spectrometer

The scintillation spectrometer[1] using a sodium iodide crystal (thallium-activated) identifies the incident gamma-ray energy with the response to the photo-electric, Compton and (when energetically possible) with the pair-production processes within the crystal. In sodium iodide, the photo-electric cross-section is predominant below about 0·2 MeV. and the pair-production process becomes appreciable above about 2·5 MeV. In the energy-range 0·2–2·5 MeV., the photo-electric and Compton processes are in competition. Thus, the recorded spectrum in this important range is complicated by the two-fold response of the spectrometer to each gamma-ray line.

Several methods of selection in favour of one of the two processes are available which simplify the interpretation of the records when a source emitting several gamma-ray lines has to be analysed. Use of a sodium iodide crystal of large dimensions enhances the photo-electric or 'total' energy peak at the expense of the Compton energy continuum, due to the capture of the scattered quanta. Substitution of anthracene, essentially a Compton absorber, for the sodium iodide crystal removes the photo-electric peaks ; the energy of the gamma-ray can then be roughly estimated from the poorly defined edge of the Compton continuum. A two-crystal coincidence spectrometer has been reported by Hofstadter and McIntyre[2]. In this method the energy absorbed by those Compton encounters which scatter the incident rays through a defined angle is measured. More recently, a method has been described by Albert[3] in which the quanta scattered by a small sodium iodide crystal are detected in a surrounding mass of sodium iodide, and the pulses due to the corresponding Compton electrons in the crystal are cancelled by anticoincidence.

In the two-crystal spectrometer described here the gamma-ray source is exposed simultaneously to sodium iodide and anthracene scintillation counters. The Compton continua from the two crystals are

qualized in height (counting-rate scale) and extent nergy scale), and then subtracted in suitable count-g-rate circuits, so that each gamma-ray energy is epresented only by a photo-electric peak in the ecorded spectrum. The method is less elegant than he two-crystal coincidence method mentioned above, ut has the advantage of allowing good geometry nd a high sensitivity with no loss in resolution. It as proved particularly valuable in analysis of mix-ures of fission products.

In the actual apparatus, duplication of the spectro-eter for each scintillation counter is avoided. The ounters have a common output connected to a pulse mplifier, single-channel pulse-amplitude analyser, ounting-rate meter and pen recorder. A motor-riven switch is used so that each photomultiplier suppressed in turn, for 0·5 sec. This involves aking an electrical connexion between the first ynode of the multiplier and the earth-connected athode for this time. Synchronized switch contacts re also provided so that the tank capacitor in the ounting-rate circuit receives a negative charge when he sodium iodide scintillation counter is in operation nd a positive charge when the anthracene scintilla-ion counter is used. The net charge on this capacitor s measured by the circuit and determines the recorded pectrum due to the photo-electric peaks only.

The simplest method of equalizing the Compton ontinua is to match the energy scales by adjusting he counter supply voltages and the counting-rate cales by arranging the source between the two rystals. The former adjustment is made for one nergy and will apply over the range for which the ulse amplitude is proportional to the energy in both ounters. The shape of the continua may be matched t the higher energies by choice of suitable sizes of rystal. This matching will not apply strictly to the ower range of energies, although here the Compton ontinuum is smaller in height relative to the photo-lectric peak. Overall, the Compton continuum may e reduced to the order of 5 per cent of the associated hoto-electric peak by this means. The effect of drifts in the electronic equipment is minimized by the use of a common power supply, common pulse amplifier, etc.

Fig. 1 shows the spectrum of a radium source as recorded by this technique, using a sodium iodide crystal of 4·4 cm. diameter and 5·4 cm. thick and a rectangular anthracene crystal 2 cm. × 2·2 cm. × 0·8 cm. The full trace shows the recorded spectrum with the Compton continuum associated with each photo-electric peak automatically subtracted. The broken trace shows the spectrum recorded by the sodium iodide crystal alone, without the subtraction of the Compton continua.

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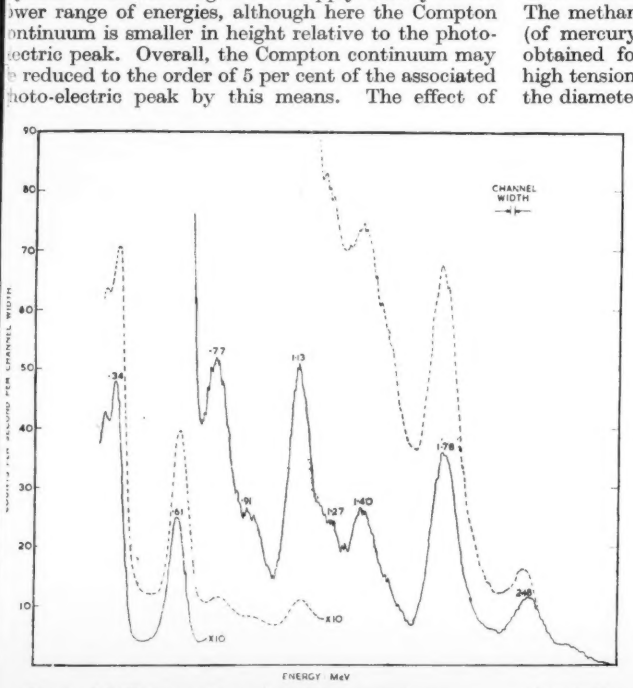

Fig. 1. Scintillation spectrograph of radium gamma-rays: ———, photoelectric peaks; – – –, photoelectric peaks plus continua

Precision Alpha-Particle Counting

This communication gives the results of an experiment designed to compare methods of absolute alpha counting at Harwell and at the Radiation Laboratory of the University of California at Berkeley. The low-geometry methane proportional chamber, used by us, has been described by Hurst and Hall[1]. The alpha-particles are collimated by three disks, to prevent reflexion from the chamber walls, and a final collimating disk to define the geometry. The alpha-particles then enter the counting chamber where the collecting electrode, a 0·001-in. diameter tungsten wire at earth potential, is held taut by a small brass ball. A concentric brass cylinder forms the cathode. The methane pressure is maintained at about 8 cm. (of mercury) and a flat plateau of ~ 600 volts is obtained for the dependence of count-rate on the high tension of the electrode. The critical dimensions, the diameter of the collimating disk and the distance of this from the source (~ 5 in.), can be measured very accurately. The geometry factor of the chamber for a point source is calculated from the difference between the solid angles subtended at the source by the collimating disk and the ball. There is a small correction for the area of the source: 0·14 per cent for a circular source of radius 0·2 in. The calculated geometry factors of our two chambers are:

Counter 12	712·5 ± 0·7
„ 13	717·3 ± 0·8

the quoted error being due to the possible errors in the dimensions used in the calculation. The chambers have been used in conjunction with the following standard British electronic equipment: power pack type 1007, amplifier type 1049*A*, potentiometer unit type 1007, scalar type 1009*A*, timing unit 1003*B* and a special head amplifier which is a modification of a type 1049*A* (to operate on negative high tension).

In the chamber used at Berkeley, the alpha-particles are collimated through a path of 40 in. and are

Table 1

Source	Harwell Chamber No. 12			Harwell Chamber No. 13			Berkeley Chamber		
	Total counts $\times 10^{-6}$	Count-rate d./min. $\times 10^{-6}$	Weighted mean d./min. $\times 10^{-6}$	Total counts $\times 10^{-6}$	Count-rate d./min. $\times 10^{-6}$	Weighted mean d./min. $\times 10^{-6}$	Total counts $\times 10^{-6}$	Count-rate d./min. $\times 10^{-6}$	Weighted mean d./min. $\times 10^{-6}$
36	not counted			1·091 0·445 1·174 0·658 0·162 0·160	1·954 1·960 1·958 1·957 1·954 1·952	1·956	3·2 1·3 1·3 3·1	1·954 1·958 1·954 1·957	1·956
37	15·756 1·000 1·012 1·033	1·169 1·169 1·163 1·168	1·169	1·574 0·326 0·409 0·164 1·552 0·038 0·095	1·169 1·169 1·166 1·171 1·168 1·169 1·169	1·169	1·2 1·3 1·8 4·4 1·1	1·163 1·162 1·164 1·164 1·163	1·164
49	1·030 1·022 1·022 1·025 1·036 0·683	8·154 8·091 8·091 8·096 8·098 8·115	8·110	1·425 1·278 0·476	8·109 8·107 8·118	8·109	4·8 12·1 9·7	8·113 8·112 8·115	8·113

detected by a zinc sulphide – silver phosphor and photomultiplier. The geometry factor is 2,635·1.

Three plutonium sources deposited on platinum disks, 0·010 in. thick, were counted in each of the chambers. The results are given in Table 1.

The lower count obtained at Berkeley for source 37 may be due to some loss of plutonium in transit. There is a small amount of plutonium-241 in these samples. This is beta unstable and decays with a thirteen-year half-life to americium-241 (alpha half-life 470 years). There is therefore a small increase in the alpha activity of the sources. This is not expected to be more than 0·2 per cent in the year which elapsed between the measurements at Harwell and at Berkeley.

The agreement between the two different methods of counting is remarkably good. We believe this is the first time such a comparison has been made to this level of precision.

We wish to thank Mr. H. P. Robinson, of the Radiation Laboratory, University of California, Berkeley, for his collaboration in these experiments. Mr. Robinson is to publish a description of his chamber elsewhere. We also wish to thank Mr. A. J. Walter for assistance in counting the sources.

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Use of Dissolved Acetylene in Liquid Scintillation Counters for the Measurement of Carbon-14 of Low Specific Activity

The application of scintillation counters to the measurement of carbon-14 of low specific activity has already been discussed[1,2] and should be particularly advantageous if large samples are available.

The possibilities of using a crystal or plastic phosphor containing the sample do not appear very practicable. A more promising method is to introduce the sample into a liquid scintillation counter either as the solvent or as a solute, or possibly as a suspended material of suitable refractive index.

Toluene with carbon-14 introduced in the side-chain would contain approximately 13 per cent by weight of the carbon to be counted, but the synthesis of pure material might prove difficult to achieve on a routine basis.

If the sample is introduced as an additional solute it is essential that it should not cause large depression in pulse-height at concentrations corresponding to approximately 10 per cent by weight of carbon.

Acetylene has already been employed in a proportional counter for radiocarbon dating[3] and a very satisfactory synthesis from carbon dioxide has been reported[4].

We have measured the solubility of acetylene in toluene at − 78° C. and at 1 atmosphere pressure, and examined its effect on a liquid scintillation counter working at this temperature. The phosphor used in the experiment consisted of 2 : 5-diphenyl-oxazole at a concentration of 3 gm./l. in toluene containing 2 per cent of ethyl alcohol. This solution remains clear when cooled to − 78° C. The count-rate due to an external source of radium γ-rays was measured for various concentrations of dissolved acetylene. At − 78° C. the phosphor solution will readily absorb more than one hundred times its own volume of acetylene, with a change in counting efficiency of approximately 23 per cent. The relation between counting efficiency and acetylene concentration is shown in Fig. 1.

A counter of 100 ml. volume could thus contain 10 litres of acetylene, which is equivalent to 11 gm.

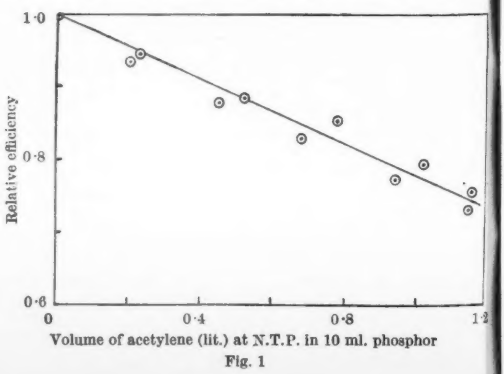

Fig. 1

of carbon. Hayes and Gould[5] report a counting efficiency of 60–70 per cent for carbon-14 with the diphenyloxazole–toluene phosphor, and it should therefore be possible to realize at least 50 per cent efficiency after addition of acetylene, even if the 23 per cent reduction observed in our experiments is not compensated by increase in amplification.

At − 78° C. the thermal noise from the photomultipliers will be substantially reduced, and with a coincidence circuit the reduction in the random noise count will be proportional to the square of the reduction factor for a single tube. Further measurements using tubes in coincidence are in progress and will be reported elsewhere.

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Crystal Structure of Parabanic Acid

A precise investigation of the crystal structure of parabanic acid has been undertaken to obtain accurate bond-lengths and bond-angles for comparison with the crystal structures of diketopiperazine[1] and cyanuric acid[2], and with its infra-red spectrum. Crystals of parabanic acid were easily obtained by slowly cooling a hot, concentrated water solution. X-ray examination showed that the crystals belong to the monoclinic system with space group $P2_1/n$, and the unit cell dimensions are: $a = 10{\cdot}684$, $b = 8{\cdot}194$, $c = 5{\cdot}044$ A.; $\beta = 92° 30'$. There are four molecules in the unit cell.

Three-dimensional intensity data were obtained from equi-inclination Weissenberg photographs. Multiple films were used, and the intensities were measured by visual comparison with an intensity scale.

Approximate positions of the atoms were obtained from a three-dimensional Patterson function, and have been refined from two-dimensional Fourier series and by three-dimensional least-squares treatment. During a late stage in the refinement of the positional parameters, a difference synthesis was computed, and this showed that the oxygen atoms had markedly anisotropic temperature factors which were very different from those of the other atoms. In order to correct for this, and to see whether this correction would affect the positional parameters, complete anisotropic temperature factors for each atom were introduced. They have the form:

$$\exp - (\alpha h^2 + \beta k^2 + \gamma l^2 + \delta hk + \epsilon hl + \eta kl).$$

These temperature factors were then refined twice by the method of least squares. A final simultaneous refinement of positional parameters and temperature factors led to calculated structure factors which were in good agreement with the observed values. The discrepancy factor $R = \frac{\Sigma|F_o - F_c|}{\Sigma|F_o|}$ is 0·094. The changes in positional parameters which resulted from the introduction of the temperature factors were small, with an average value of 0·003 A.

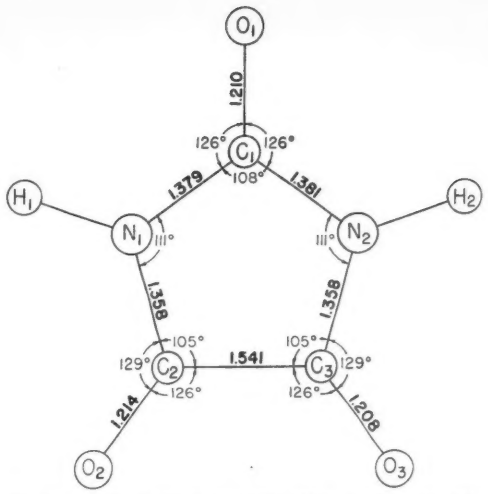

Fig. 1. The bond-lengths and bond-angles of parabanic acid

The structure consists of planar molecules inclined by 36° to the (010) plane. Neighbouring molecules related by the *n* glide plane are linked in sheets by NH . . . O hydrogen bonds. The lengths of these bonds are $N_1 \ldots O_{3'} = 2{\cdot}874$; $N_2 \ldots O_{2''} = 2{\cdot}835$ A. The oxygen of the unique carbonyl group is not involved in hydrogen bond formation. The bond-lengths and bond-angles of the molecule are shown in Fig. 1.

A more detailed account of this work will be published elsewhere.

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Direct Observation of Polygonization in Rocksalt

Polygonization has been studied hitherto by means of two different methods: Guinier and co-workers[1] used refined X-ray methods, which, however, only permit the detection of orientation differences without localizing the domain responsible for a particular spot; Cahn and others[2], on the other hand, used etching techniques to make visible the polygon boundaries. The mean difference of orientation was estimated from the radius of curvature of the bent specimen and the width of the domains.

We describe here a further simple approach to the study of polygonization, based on the property of cleavage. When a crystal is polygonized, it is in fact to be expected that its cleavage faces will be polygonal. This has now been confirmed by observations on sodium chloride crystals. The method permits direct observation of the domain and an accurate measurement of the differences of orientation.

Konobejewski and Mirer[3] have observed by means of the Laue method that bent crystals of sodium

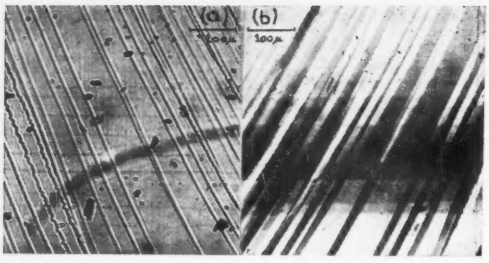

Fig. 1. Polygonization domains in rocksalt as observed on a cleavage face: (*a*) ordinary light; (*b*) Françon method of observation

chloride readily become polygonized after suitable heat treatment. We have bent small cleavage prisms of synthetic rocksalt under warm water and annealed them during 6 hr. (in a typical case) at 600° C. In order to produce a face suitable for observation, the specimens were cleaved again very carefully, following the two cube planes parallel to the axis of bending. The cleavage faces were then silvered and examined by means of a polarizing petrographic microscope. When using bright-field illumination at normal incidence, remarkably straight lines parallel to the axis of bending were faintly visible on both cleavage faces (Fig. 1*a*).

These lines are the boundaries of the polygon domains. They could be made much better visible using one of the methods of observation introduced by Françon[4]. The method consists in putting a Savart polariscope in the 45 deg. position in front of the objective. When working with crossed nicols, orientation differences are seen as colour differences in white light, and as intensity differences in monochromatic light. A step is seen as a narrow strip of different colour or of different intensity. Fig. 1*b* shows a cleavage face of sodium chloride observed by means of this method. The difference in orientation of the domains is now readily visible, and it is also evident that within a domain the cleavage face is flat apart from steps produced by cleaving. It was found that the dislocation walls are perpendicular to the slip vector $\frac{1}{2}[110]$, as is to be expected from theory[5].

It is now possible to measure accurately the orientation difference across a particular boundary as well as the local curvature, using one of the multiple-beam interferometry techniques introduced by S. Tolansky[6].

This work is part of a research scheme supported by I.R.S.I.A. (C.E.S.). I wish to thank Prof. W. Dekeyser for his interest and Prof. M. Françon for the loan of equipment.

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Multilayer Dielectric Reflecting Films at Wave-lengths between 4000 and 4600 A.

In a previous communication[1], we gave some measurements of the performance of multilayer dielectric interference filters in the wave-length range 4000–4600 A. We are grateful to M. P. Giacomo for first pointing out that, in deducing from our results the properties of dielectric reflecting films, we failed to take into account the variation of phase change with wave-length, which has been treated by Dufour[2]. His results show that in our case the filters should have been considered not as of first order, but as of order 2·45. Our values of the reflexion, transmission and absorption coefficients for seven-layer reflecting films of cryolite and zinc sulphide on glass are then as in the table.

λ	4100 A.	4300 A.	4500 A.
Reflexion coefficient	0·956	0·958	0·960
Transmission coefficient	0·027	0·030	0·032
Absorption coefficient	0·017	0·012	0·008

Our conclusions that seven-layer dielectric films are superior to silver films as Fabry–Perot interferometer coatings at these wave-lengths still, however, remains valid. The 'effective number of interfering beams' for the former is about 95 at λ 4,200, which is more than sufficient to take advantage of the best-quality optical flats.

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Electrolytic Corrosion of Iron and Copper

It is generally accepted that if cast iron and copper are coupled together in a brine solution, the iron, being the less noble member, is likely to suffer corrosion. The copper, on the other hand, will be made 'more negative' by contact with the iron and will be prevented in greater or less degree from corroding. The classical work on this subject was that of Sir Humphry Davy, and is well known to electro-chemists and to corrosion engineers.

A short time ago, I had an opportunity of inspecting a large cast iron vessel, used for heating brine, in the central region in which was fixed a system of copper tubes. After many years successful use, a considerable degree of corrosion had become evident on the upper ends of the copper tubes and end plate, and this apparently was of fairly recent origin. The conditions of use had not apparently changed, but it became clear that the cast iron in this vicinity had gradually become heavily graphitized. Experiments made on samples of copper coupled to graphitized cast iron in saturated brine solutions showed that surprisingly heavy currents could flow in a direction which made the copper the anode with considerable dissolution of this metal. That is to say, the graphitized cast iron was considerably more noble than copper, whereas normally cast iron is less noble. This fact does not appear to have been recorded previously, and if it is at all a general phenomenon it raises important considerations in relation to the coupling

copper service pipes to older cast iron gas and ater mains, many of which may have become aphitized in the course of years, as well as in other mmercial applications.

An interesting sidelight on this phenomenon, which deed may seem obvious enough when attention is rected to it, is that Davy, using zinc, malleable n and cast iron in his experiments on the pro-ction of copper sheathing of the hulls of warships, pressed a preference for cast iron rather than alleable on the grounds that "it lasts longer than alleable iron or zinc; and the plumbaginous sub-ance, which is left by the action of seawater upon retains the original form of the iron and does not pede the electrical action of the remaining metal". It now appears that after the first stage, when the n has been sufficiently removed by dissolution in function as an anode, the "plumbaginous sub-ance" remaining may actually bring about a versal of the polarity and lead to a dissolution of e copper instead of its protection as intended.

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Physical Studies on Ribonucleic Acid

We have recently taken X-ray photographs of bonucleic acids (RNA) from various sources. wdered or lyophilized specimens from tobacco saic virus, turnip yellow mosaic virus, calf liver, lf thymus (two preparative techniques) and yeast ve been examined. The photographs appear to identical (Table 1), suggesting that there is an derlying three-dimensional configuration common all ribonucleic acids, despite the large differences the purine–pyrimidine ratios[1]. Of course, the non-ystallinity of the specimens would preclude the tection of minor differences between the patterns. should be noted that these X-ray powder patterns e different from those obtained from deoxyribo-cleic acid (DNA)[2].

An interesting transformation in these patterns is served on raising the relative humidity above 90 per nt. A 'wet' form is obtained with the powder rings tered as listed in Table 1. The outermost rings are tered very little, but the inner rings are changed eatly both in position and intensity and have an creased sharpness indicative of more long-range der. This transformation of 'dry' to 'wet' forms readily reversible.

Fibres of ribonucleic acid were obtained by a chnique based on that used by Wilkins and his o-workers[3] in their work on deoxyribonucleic acid. Distilled water was added to a small sample of bonucleic acid with a micropipette. When the material was sufficiently gelatinous, a small glass fibre was dipped into the material and slowly withdrawn, using a microscope stage and ocular tube for controlling the process. A small amount of material adheres to the glass fibre and, by controlling both the speed of withdrawal and the water content, fibres have been obtained more than a centimetre in length, and with diameters down to 5 μ. Upon air drying, the fibres become quite brittle and can be readily manipulated for optical investigation.

Table 1. Spacings observed in Powder Photographs of Ribonucleic Acid from Various Sources

'Dry' form		'Wet' form	
Spacing (A.)	Intensity	Spacing (A.)	Intensity
		24·3	very strong
10·1	medium	11·3	strong
7·0	very weak	7·3	weak
5·3	medium	5·4	medium
3·9	,,	3·9	,,
3·2	,,	3·2	strong

Not all ribonucleic acid preparations could be drawn into fibres. For example, one of the two preparations of calf thymus ribonucleic acid could be drawn into fine fibres, whereas the other would produce no fibres at all, probably because of partial depolymerization. Nevertheless, they gave identical X-ray powder patterns.

The fibres are birefringent, and many show complete extinction under the polarizing microscope. The birefringence is negative like that of deoxyribonucleic acid and usually has a magnitude of 0·02, with occasional sections running as high as 0·04. Just as in deoxyribonucleic acid, the negative birefringence probably reflects an orientation of the nucleotide bases more nearly perpendicular than parallel to the fibre axis.

The changes in the X-ray powder pattern of ribonucleic acid at various relative humidities may be correlated with changes in the macroscopic properties of the fibres. Upon raising the relative humidity from 35 per cent (air-dried fibre) to 95 per cent, the length increases by approximately 25 per cent and the diameter by 20 per cent, without a marked change in birefringence. The water content of this material increases from 12 per cent of dry weight in the air-dried form to 80 per cent at a relative humidity of 95 per cent. If the humidity is lowered, the fibres will contract again almost to their original length. At relative humidities near 100 per cent, the fibres slowly lose their birefringence and shape, and form amorphous masses.

If, in drawing out the fibres, one increases the tension rapidly, they often give way at a point to form a narrower section. This 'necked' region is positively birefringent, in contrast to the rest of the fibre, and is separated from the unaltered regions of negative birefringence by small regions of zero birefringence. The magnitude of the positive birefringence is variable but has been measured as high as + 0·02. A phenomenon similar to this has been observed by Wilkins *et al.* with deoxyribonucleic acid fibres[3]. As with deoxyribonucleic acid, releasing the tension and placing the fibre in a moist atmosphere brings about a reversal to a state of negative birefringence. Thus, it appears that both ribonucleic and deoxyribonucleic acid can exist in two states, one unstretched and negatively birefringent, the other stretched and positively birefringent.

X-ray photographs of ribonucleic acid fibres have been obtained which show fibrous orientation. A detailed discussion and interpretation of these photographs will be the subject of a future publication.

These investigations of ribonucleic acids from various sources point to the existence of a common structure. Moreover, the fact that ribonucleic acid can be drawn into fibres capable of giving oriented X-ray fibre patterns implies that it is a long asymmetrical molecule, which is in agreement with some recent physical chemical characterizations of ribonucleic acid[4]. Although they are quite distinct molecules, we see from the above that the similarity

between ribonucleic and deoxyribonucleic acids extends not only to their chemical constitution and linkages[5], but also to some of their physical properties.

We wish to thank Drs. C. A. Knight, E. Volkin, R. Markham, A. L. Dounce and N. Simmons for their generous co-operation in providing samples of ribonucleic acid. Further details of this investigation will be published at a later date.

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The Carbohydrate of Connective Tissue

In a recent paper[1] on the mucopolysaccharides of bovine cornea, Meyer, Linker, Davidson and Weissmann conclude that "keratosulphate is the only sulphated polysaccharide of animal origin which does not contain a uronic acid as one of its main constituents", and they showed that it contained N-acetylglucosamine and galactose in equimolecular proportions and formed about half the total polysaccharide present.

Recently[2], we postulated the presence of uronic acid-free polysaccharide consisting of glucosamine, galactose and probably mannose, as forming the major polysaccharide component of subcutaneous connective tissue. These three sugars have also been shown by Glegg, Eidinger and Leblond[3] to occur as major constituents in the carbohydrate components of other types of connective tissue, an observation which has also been confirmed in these laboratories (unpublished). It is considered of interest to summarize some recent investigations which have demonstrated at least two uronic acid-free acid polysaccharides in subcutaneous connective tissue, probably forming the bulk of the bound polysaccharides present.

By treatment of human abdominal subcutaneous connective tissue, previously freed from fat and water-soluble material, with $N/5$ potassium hydroxide at 0° for fourteen days, carbohydrate and protein were extracted. Three fractions were isolated from the solution, amounting altogether to about 6 per cent of the original weight. Two were insoluble in dilute acetic acid and formed about 75 per cent of the extracted material; the third was readily soluble in acetic acid. The carbohydrate content of the three fractions was 10–20 per cent, and on mild acid hydrolysis, the sugars released from all the fractions were demonstrated, by chromatography and ionophoresis on paper[4], to be chiefly hexosamine, galactose and mannose, with galactose predominating over mannose. Relatively small amounts of other sugars were present, but uronic acid was not observed, and the small amounts of colour produced by the Dische method for uronic acid[5] could largely be accounted for by the hexoses present.

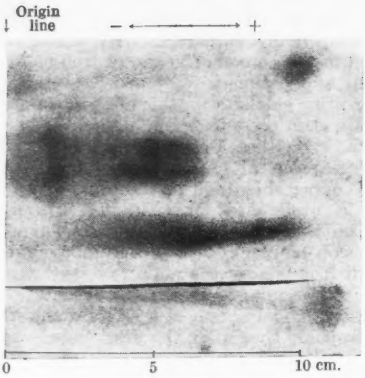

Fig. 1. Electrophoresis of fractions from human subcutaneous tissue. Whatman No. 1 paper. Phosphate buffer pH 7 at 10·3 V./cm. for 2 hr. Toluidine blue stain. *a*, *b*, Acetic acid – insoluble fractions; *c*, acetic acid – soluble fraction; *d*, cartilage chondroitin sulphate (50 μgm.). 0·5–1 mgm. of each fraction used

Acidic polysaccharides were demonstrated by electrophoresis on paper, followed by staining with toluidine blue, a method similar to that of Rienits[6]. Fig. 1 is a photograph showing at least two metachromatic components with moderate to high mobility towards the anode and a third component of low mobility present only in the acetic acid–insoluble fractions. None had the same mobility as cartilage chondroitin sulphate, and a two-dimensional separation (chromatography followed by electrophoresis) further demonstrated their non-identity with chondroitin sulphate. This is illustrated for the acetic acid–soluble fraction in Fig. 2. The presence of sulphate groups, while not yet proved, may be

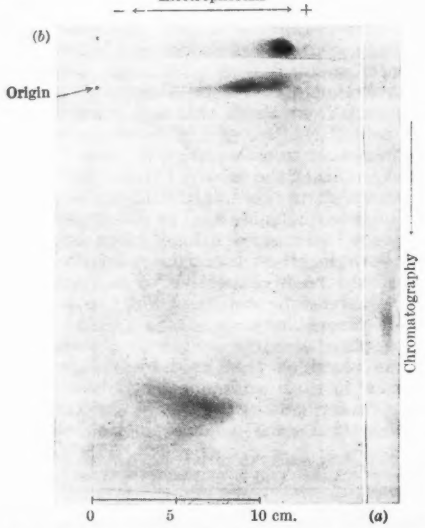

Fig. 2. Two-dimensional separation of acetic acid – soluble fraction. Solution containing 2 mgm. applied at origin on Whatman No. 1 sheet. Chromatography in 2 : 6 lutidine, *tert.* butanol, water (1 : 1 : 2) for 17 hr. followed by electrophoresis as described under Fig. 1. *a*, Chromatogram control with 40 μgm. chondroitin sulphate on same sheet and removed before electrophoresis; *b*, electrophoresis control with 40 μgm. chondroitin sulphate on same sheet

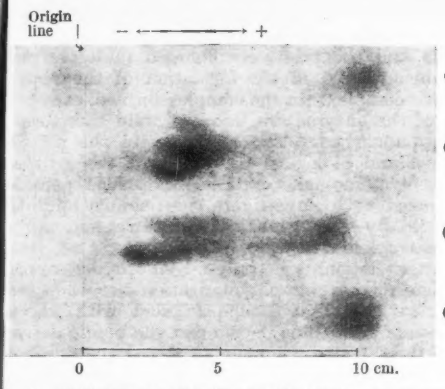

Fig. 3. Electrophoresis of polysaccharide fractions from young rabbits. Conditions as described under Fig. 1. *a* and *d*, Chondroitin sulphate (50 μgm.); *b*, subcutaneous tissue extract; *c*, skin extract. About 1 mgm. of each extract used

differed from mobility, metachromasia and absence of uronic acid. The two faster components have also been observed in polysaccharide extracted from adult rabbit subcutaneous tissue by the comparatively mild procedure of Einbinder and Schubert[7], and the slow component was present only in extracts from which protein had not been afterwards completely removed by the Sevag method. Extracts from young rabbit subcutaneous tissue, prepared in this way, were found to be almost free from the fast component; but this and the moderately fast component were present in the skin extract. This is illustrated in Fig. 3. Hydrolysis of the rabbit extracts released sugars similar to those found in the human extracts.

These observations suggest that polysaccharides of a type similar to 'kerato sulphate' are present in connective tissue other than cornea.

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Free-Radical Activity of Reinforcing Rubber Fillers

In our studies on the mechanism of rubber reinforcement, we were led to assume that primary valency bonds are likely to form between an 'active' filler and the rubber-matrix via free radical intermediates. The hypothesis was based on the following considerations:

(*a*) Although a strong school of thought still maintains that the strength of bonding depends mainly on van der Waals's forces, and therefore on particle size[1], there is a number of individual observations which suggest the presence of 'reactive sites' and formation of strong bonds of a chemical nature between filler and rubber[2]. Foremost among these is the phenomenon that the incorporation of active pigments such as carbon blacks, silicas and the like into rubber results in the insolubilization of a part of the rubber[3]. This part is conveniently called 'bound rubber' or 'carbon-gel'.

(*b*) E. H. Farmer and his school have shown that the vulcanization process is based on a free-radical mechanism wherein a number of the rubber double-bonds and α-methylene groups, sulphur and accelerator are involved, resulting in the formation of three-dimensional giant networks[4]. The mechanism of mastication is also known to consist in the production of free radicals in the presence of suitable 'radical acceptors', such as oxygen[5].

(*c*) There are some common features in both reinforcement and vulcanization, such as crystallization effects[6].

(*d*) Little or no reinforcing action of otherwise active pigments is observed with saturated polymers, for example, poly*iso*butylene[7].

Correlation of these facts appeared most plausible if we assumed that the formation of chemical bonds between pigment and rubber constitutes an integral part of the chemical cross-linking that may commence in the rubber mill and is completed by vulcanization, all the interacting partners exhibiting free-radical character at one stage or the other. To test this hypothesis we have studied the reactivity of pigment surfaces towards simple organic and inorganic free radicals. (Controls with the corresponding ionic species were included to ensure that the effects observed were due to free-radical reactions.)

Although the results will prove of particular interest in the rubber field, they are also likely to throw new light on the problem of 'chemisorption' and also, perhaps, on the nature of 'catalytic activity' of some solids of interest in other fields. The results are briefly as follows.

Active pigments react with free radicals with the formation of new primary valency bonds. Thus, certain reinforcing blacks can, by the attachment of SO_4^{2-} free radical ions, be made hydrophilic; they are easily dispersed in water to form stable colloidal suspensions.

Introduction of organic free radicals such as $C_6H_5—\overset{\overset{O}{\|}}{C}—O\cdot$ or $C_{17}H_{35}—\overset{\overset{O}{\|}}{C}—O\cdot$ yields chemically modified pigments, showing markedly changed dispersion and wetting characteristics in various solvents.

Mono-oxidation products of certain diamines, such as 'benzidine blue' derived from benzidine, being semi-quinones in character, easily react even with less-active pigments (for example, silicas) and thus provide a useful measure of activity.

From the experiments with free radicals the number of active centres for a series of fillers has been calculated and found to cover a range of 0·01–2·3 per 100 sq. A.

Multifunctional organic free radicals, such as polystyrene di-radicals, as may be set up in the course of uncatalysed mass-polymerization at moderate temperature, on reaction with active carbon blacks, form cross-linked electrically conducting gels which resist solvent extraction. These are considered to be complete analogues of the well-known rubber–carbon–gels. The mechanism of their formation, namely, by a free radical reaction, is strongly supported by the

lack of gel-formation if polystyrene granules are dissolved and an active pigment added to the solution.

Oxidation reactions of pigment surfaces at temperatures of 50–70° C. were studied by the well-known Russell technique. Exposure of photographic emulsions to pigments gave results of a very complex nature. By using suitable screening agents, we have been able to detect at least three different effects: (i) luminescence, (ii) a 'pseudo photographic' effect as produced by oxidizing agents, hydrogen peroxide being the most common fog-producing material, and (iii) an 'emission'. From the evidence obtained so far the last is considered to consist of low-energy electrons (probably less than 10 eV.) that are made available by an oxidation mechanism comparable to the Kramer effect with freshly abraded metal surfaces.

Pigments of comparable particle-size are not equally active towards free radicals. The photographic results also show pronounced differentiation as regards ability of different pigment surfaces to affect photographic emulsions. It therefore appears that small particle-size of a pigment is a necessary though not sufficient condition for activity.

The evidence obtained seems sufficient to suggest that reinforcing blacks and also a number of inorganic 'active' fillers can act as single-electron donors and can, in the presence of radicals or 'radical acceptors', produce chemically modified solids by the formation of new primary valence bonds. It furthermore would appear worth while to investigate the actinic effects of free radicals generally, since, in a way, they may be regarded as single electrons attached to material particles.

A full account of the rubber aspects of this work will be presented at the forthcoming Third Rubber Technology Conference, London.

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Reversible Inhibition of Pepsin by Polylysine

The mode of action of low-molecular weight enzyme inhibitors has been intensively studied. This does not, however, apply to high-molecular weight enzyme inhibitors. So far as we are aware, no work has been published on synthetic high-molecular weight enzyme inhibitors, and the mode of action of natural high-molecular weight enzyme inhibitors, such as the pepsin inhibitor and the various trypsin inhibitors, is still not fully understood.

A natural pepsin inhibitor was isolated from pepsinogen in a crystalline form by Herriott[1], who identified it as a basic polypeptide of molecular weight 5,000–10,000, containing a high percentage of arginine. As pepsin behaves electrophoretically as a strong acid, it could be assumed that the electrostatic attraction between the negatively charged enzyme and the positively charged inhibitor plays a significant part in the formation of the pepsin-inhibitor complex. In the complex formed, the active areas of the enzyme are 'masked', and therefore its activity abolished. The similarity in the physico-chemical and biological properties of the synthetic basic polyamino-acids and natural basic peptides encouraged us to investigate the possible inhibition of pepsin by polylysine, polyornithine and poly-*p*-aminophenylalanine.

Constant amounts of poly-L-lysine hydrobromide (average degree of polymerization $n = 36$) were mixed in $0{\cdot}06\,N$ hydrochloric acid with varying amounts of crystalline pepsin and the peptic activity of the mixtures to hæmoglobin tested spectrophotometrically, as described by Anson[4]. The effect of increasing amounts of pepsin, at three concentrations of polylysine, on the amount of pepsin inactivated (pepsin combined) is given in Fig. 1. The sets of values for constant polylysine concentrations at *p*H 1·7 resemble closely those obtained by Herriott[1] for the natural pepsin inhibitor at *p*H 5·7. The continuous lines in Fig. 1 were obtained by assuming the reversible reaction:

$$\text{Pepsin} + \text{polylysine} \rightleftharpoons \text{pepsin} - \text{polylysine compound}$$

$$\frac{[\text{Pepsin}]\,[\text{Polylysine}]}{[\text{Pepsin} - \text{polylysine compound}]} = K$$

in analogy with Herriott's assumption for the natural inhibitor. The total concentration of polylysine can be expressed as a pepsin equivalent derived from the amount of pepsin which combines with the synthetic inhibitor at a large excess of enzyme. The value of $K = 0{\cdot}5 \times 10^{-4}$ [P.U (Hb, ml.)] is then found to fit best the experimental results.

The inhibitory action of polylysine seems to be instantaneous, for the pre-incubation of pepsin with polylysine at room temperature from five to thirty minutes did not change the extent of inhibition. The reversibility of the interaction between pepsin and the synthetic basic peptide was ascertained by the observation that solutions containing the enzymatically inactive pepsin – polylysine complex regained full peptic activity in the presence of a large excess of heparin. The restoration in enzyme activity has probably been caused by the formation of a complex between the basic polylysine and the strongly acidic heparin according to the following scheme:

$$\text{Pepsin} - \text{polylysine compound} + \text{heparin} \rightarrow \text{pepsin} + \text{polylysine} - \text{heparin compound}$$

The importance of positively charged groups in the high-molecular weight synthetic pepsin inhibitors was demonstrated in parallel experiments with various water-soluble polyamino-acids, where it has been shown that the basic polyornithine and poly-*p*-aminophenylalanine act similarly to polylysine as pepsin inhibitors, while poly-DL-alanine and the polyaspartic and polyglutamic acids show no inhibitory effect.

It is of interest to note that, while the natural pepsin inhibitor inhibits pepsin activity between *p*H 5·0 and 6·0, polylysine shows marked inhibitory effect both at *p*H 1·7 and *p*H 6·0 (the inhibitory effect at this *p*H was demonstrated by the rennet test[1]). The interaction of polylysine with pepsin at a *p*H as low as 1·7 is probably the result of the large number of positive charges on the peptide and negative charges on the enzyme at these low

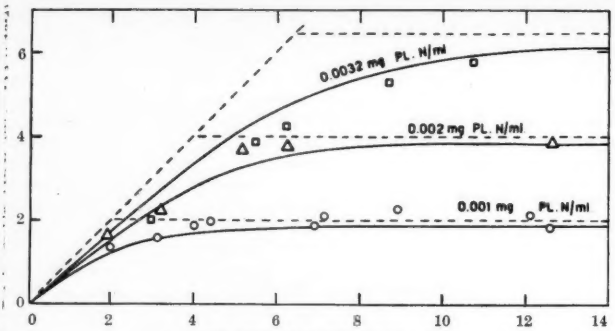

Fig. 1. The effect of increasing amounts of pepsin and poly-L-lysine (PL) (average degree of polymerization $n = 36$) on the amount of pepsin bound by the inhibitor, at *p*H 1·7. The points are the determined values. The solid lines are the theoretical curves calculated from the mass law, as indicated in the text. The broken lines indicate the course of the reaction if it were stoichiometric, that is, $K = 0$

*p*H values. Contrary to the natural pepsin inhibitor, polylysine is resistant to pepsin hydrolysis.

The similarity in the solubility of polylysine and the natural pepsin inhibitor in trichloroacetic acid, as well as the precipitation of both with tungstic acid at *p*H 2·0, enabled us to demonstrate that polylysine may be isolated from a pepsin – polylysine compound by the application of Herriott's method[1] for the isolation of the natural pepsin inhibitor from pepsinogen.

This investigation is supported by a research grant (*PHS G*-3677) from the National Institutes of Health, Public Health Services, U.S.A.

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Nucleus Formation and Cleavage induced in Unfertilized Rat Eggs

Rabbit eggs subjected *in vivo* to cold-shock treatment seldom abstrict the second polar body[1], but frequently form one or two nuclei, resembling pronuclei, and may later undergo cleavage[1,2]. The response of the rat egg to cold-shock is different, in that the abstriction of the second polar body regularly occurs and the group of chromosomes remaining within the egg commonly becomes scattered[1,3]. Nucleus formation and cleavage have not been seen, but mostly the observations were restricted to a period of a few hours after the application of the stimulus.

It has now been found that, after cold-shock treatment, a small proportion of rat eggs will undergo apparent early parthenogenetic development. Cold-shock was applied to the eggs of 130 œstrous rats under 'Nembutal' anæsthesia 8–12 hr. after ovulation. The rats were killed during the succeeding two days. Among the 957 eggs recovered, 98 eggs showed nucleus-formation of nuclei or stages of cleavage; the features exhibited depended upon the time-interval between operation and slaughter.

Some of the rats were killed at 18–22 hr. and yielded thirty-five nucleated undivided eggs. In twenty-nine of these, there was a single large well-formed nucleus resembling a normal male pronucleus at full development (Fig. 1). The other six nucleated eggs had two nuclei each, which suggested in appearance male and female pronuclei, and which probably resulted from partial scatter of the chromosomes prior to nucleus formation. Polar bodies were evident in twenty-five mononucleate and in all binucleate eggs; these were regarded as second polar bodies because the first has been found to persist in only 1·3 per cent of rat eggs[3], and emission of the second follows cold-shock[1,3].

Rats killed at 20–22 hr. after operation provided eight eggs that showed groups of chromosomes arranged as in the anaphase and telophase spindles of the first cleavage division.

The remaining fifty-five eggs were recovered from rats killed between 24 hr. and 48 hr. after operation; they had undergone cleavage and strongly resembled fertilized 2-cell eggs in the evenness of the blastomeres, the texture of the cytoplasm and the form of the nuclei (Fig. 2). Polar bodies were identifiable in most of the eggs.

It was noted earlier that unfertilized rat eggs may spontaneously undergo fragmentation in such a way as superficially to resemble the cleavage stages of fertilized eggs[4]. In none of these 'pseudo-normal' eggs, however, was the nuclear state normal; in the great majority, the nucleus was completely lacking or was represented by subnuclei only. Spontaneous formation of an apparently normal nucleus can occur; but we have seldom observed it[5].

It was concluded in the paper already referred to[4] that the unpenetrated rat egg has a tendency towards parthenogenetic development. The cold-shock treatment, by inducing the abstriction of the second polar body, evidently facilitates the expression of this tendency. The phenomena of nucleus formation and cleavage described in the present communication may be regarded as evidence of parthenogenetic development for two reasons: first, the nuclei are very similar to pronuclei of to normal 2-cell nuclei and, secondly, the processes leading up to and including the first cleavage correspond, both in general features and in time-relations, to the pronuclear growth, mitosis and cleavage of fertilized eggs. Whether extensive parthenogenetic development is possible has not been determined. Nevertheless, these artificially activated eggs are of special interest,

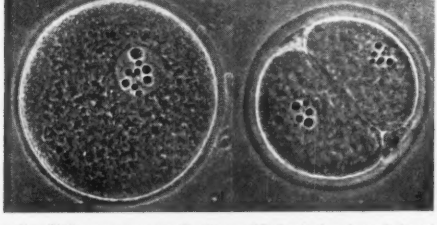

Fig. 1. Rat eggs recovered after cold-shock treatment *in vivo*. (1) Undivided egg showing single large nucleus. (2) Egg in 2-cell stage, showing well-formed nuclei. Both eggs slightly compressed by coverslip. × 250

because regular extrusion of the polar body means that they are almost certainly haploid. Study of the induced nuclei in 1-cell and 2-cell eggs may thus help to throw light upon the conditions influencing size and form in normal pronuclei and nuclei. This problem is the subject of a more detailed report which is being prepared for publication elsewhere.

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Metabolism of Gamma-Benzene Hexachloride in the Animal Body

In order to gain a better insight into the means of defence against benzene hexachloride (BHC) intoxication, which the animal organism has at its disposal, the metabolism of this insecticide has been the object of investigations in our laboratory.

For the quantitative assay of the toxicant in animal tissues we used a method[1] which combines the simplicity of the method described by Reith[2] for qualitative purposes with the accuracy of the method published by Schechter and Hornstein[3]. The principle of this method consists of dechlorination of BHC to benzene by means of zinc dust in acetic acid, nitration of benzene to dinitrobenzene and colorimetric determination of the intensely violet-red reaction product formed by the latter compound with methyl ethyl ketone and alkali.

A series of related substances has been tested by this method. Only the four principal isomers of BHC and benzene gave a positive reaction. No colour at all was obtained with phenol, meso-inositol, hexamethoxy cyclohexane, trichloro benzene and monochloro cyclohexane. Moreover, scarcely any colour was obtained after running control analyses on the tissues of untreated animals. We are inclined to consider the method rather specific. Nevertheless it is possible that a positive colour reaction will be shown by metabolites of BHC.

After subcutaneous, intraperitoneal or intravenous injection of gamma-BHC into albino mice a rather rapid breakdown of the toxicant could be observed. A subcutaneously injected dose of 1 mgm. gamma-BHC was eliminated in the course of four days by a mouse of about 15 gm. weight. When 200 μgm. of gamma-BHC was injected intravenously (in peanut oil–Ringer emulsion) all the toxicant had disappeared within twenty-four hours. The excreta contained no BHC, or only negligible amounts; the amounts in brain, liver, kidney and muscle tissue after subcutaneous, intravenous and oral administration turned out to be rather low. Mostly only 20 μgm. or less per gram of tissue were found. Accumulation of the toxicant in these tissues could not be demonstrated. There are some indications that gamma-BHC may be accumulated in the fat depots of the body. However, it should be kept in mind that BHC was injected in oily solution.

A rather rapid breakdown of gamma-BHC was also observed in resistant houseflies; twenty-four hours after injection of 22 μgm. per gram of animals, only negligible amounts could be recovered. Here, too, none was found in the excreta. One of us (F. J. O.) deals with this subject in the following communication.

As to the nature of the metabolites of gamma-BHC we are entirely ignorant. It should be emphasized that breakdown in the above sense and detoxication (conversion into a non-toxic compound) need not parallel each other.

Investigations concerning the metabolism of other isomers of BHC are in progress now. Moreover, a closer study of the correlations between the symptoms of intoxication and the course of the metabolic changes after administration of different isomers of BHC is to be made.

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Metabolism of Gamma-Benzene Hexachloride in Susceptible and Resistant Houseflies

The metabolism of gamma-BHC was studied in three strains of houseflies: a susceptible strain (*S*) and two gamma-BHC-resistant strains (R_1, R_2), one of which was also resistant to DDT (R_2). The method used was as described in the preceding communication.

The flies were injected into the thorax with 0·3 μgm. gamma-BHC in 0·3 mm.³ of an emulsion of peanut oil. Groups of seventy flies, thus receiving 22 μgm., were kept at 25° C. for varying periods of time, after which the amount of gamma-BHC was estimated. As no gamma-BHC was found in the excreta, a decrease of the amount of the toxicant in the flies indicates that it is metabolized.

It is shown in Fig. 1 that a rapid breakdown occurs in the resistant strains, and that the susceptible strain is also able to metabolize the poison. In the latter the process is slower at the beginning and eventually it ceases completely. This can perhaps be explained by the fact that in these flies heavy symptoms build up soon after injection, followed by death after a few hours.

In a number of experiments the abdomens were cut off thirty minutes after injection. It could be shown that the breakdown is going on for at least four hours in both parts of the body. It follows that neither the Malpighian tubes nor the fat body can be the only site of the breakdown. Thirty minutes after injection the abdomens, which represent only 25 per cent of the body-weight, contained more than half the poison present. As they contain 75 per cent of the body-fat, it is likely that storage in the fat depots occurs, which also seems to play a part in mice (see preceding communication).

A rapid breakdown in susceptible flies may perhaps also be inferred from the data of Bradbury *et al.*[1]. Using radioactive gamma-BHC they found an uptake of 34 μgm. per gram of flies in four hours, an amount which would rapidly have killed their flies if no

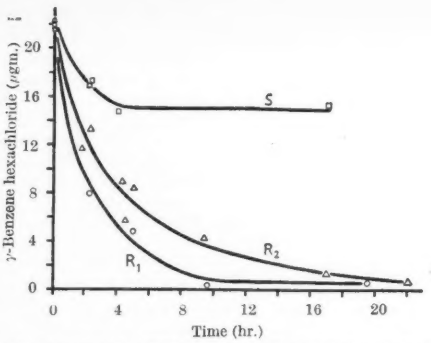

Fig. 1. Amount of γ-BHC in seventy flies plotted against time after injection. *S*, susceptible strain, dying after a few hours; R_1, γ-BHC-resistant strain; R_2, γ-BHC- and DDT-resistant strain

etoxication had occurred. It should be stressed that ıe metabolism found in our experiments need not arallel a detoxication process.

The question whether a difference in breakdown etween susceptible and resistant strains is the cause f their difference in susceptibility remains to be ettled. A comparison between the two strains, of ourse, should be made at concentrations at which oth will survive. Work on this subject is in progress ı our Laboratory.

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Relation of the Paraventricular Nucleus to the Pituitary Gland

It is well known that the supra-optic nucleus innervates the posterior pituitary gland and that a otal, bilateral destruction of this nucleus or a complete section of the supra-optico-hypophysial tract esults in diabetes insipidus[1].

Since an interruption of the hypophysial stalk or removal of the posterior lobe[2,3] is followed by a ertain loss of cells in the paraventricular nucleus, is possible that this nucleus also takes part in the innervation of the posterior lobe. Whether this loss f cells is the result of a direct retrograde reaction r of a transneuronal degeneration is, however, unnown. On the whole, the closer fibre connexions f the paraventricular nucleus are not clear, and the unction of the nucleus is completely unknown.

The relation of the paraventricular nucleus to the hyrotrophic and to the adrenocorticotrophic hormones of the anterior lobe, and to the hormones of ne posterior lobe, has therefore been investigated by sing small, circumscribed, bilaterally symmetrical lectrolytic lesions in the diencephalon of rats.

The lesions were made with an instrument described by Hillarp[4], and with this technique it has been possible serially to destroy completely the paraventricular nuclei without destroying the adjacent nuclear areas. The strength of the current was 0·5 m.amp. for 20 sec. For exact localization of the lesions the hypothalamic region was fixed in Carnoy's fluid, and cut in serial sections of 10 μ. The sections were stained in gallocyanin according to the method of Einarson.

The thyrotrophic function was studied by thyroidectomy, which produces increased thyrotrophic activity of the hypophysis with the appearance of thyroidectomy cells in the anterior lobe.

As an indicator of the secretion of adrenocorticotrophic hormone, the cholesterol content in the adrenal glands was determined after the animals had been exposed to cold with temperatures between 0° and + 4° C. One adrenal was removed before, the other after, the exposure to cold so that a comparison could be made before and after stress between the two adrenals from one animal.

Isolated posterior lobes from animals with hypothalamic lesions were extracted in acid solution, and tested for oxytocin according to the method of Pamela Holton[5] and for vasopressin by Dekanski's method[6].

Concerning anterior lobe hormones, it could be shown that in animals with a total, bilateral destruction of the paraventricular nuclei there appeared after thyroidectomy abundant thyroidectomy cells in the anterior lobe, and that there was, after stress, a lowering of the cholesterol content of the adrenals of about the same degree as the controls. The paraventricular nucleus, then, cannot be a hypothalamic centre for the thyrotrophic and adrenocorticotrophic functions of the hypophysis.

Regarding the hormones of the posterior pituitary, there is agreement that the antidiuretic hormone and vasopressin are identical. Whether there is in the posterior lobe a single large molecule from which the active fractions break off, or whether the antidiuretic–vasopressor hormone and oxytocin physiologically exist in the posterior lobe as two different, active substances has not definitely been decided.

The tests for the hormones of the posterior pituitary lobe showed that, after hypothalamic lesions with total bilateral destruction of the paraventricular nuclei, there was a complete disappearance of oxytocin, and that, after lesions leaving only a few cells of the nuclei intact, there was a lowering of the oxytocin in the posterior lobe to less than 20 per cent of the normal. Posterior lobes from animals with lesions in the vicinity of the paraventricular nuclei but leaving these structures intact showed normal content of oxytocin.

A posterior lobe completely lacking oxytocin showed on simultaneous investigation for vasopressin normal pressor effect.

These experiments thus show that in the rat's posterior pituitary lobe there are two different hormones, namely, the antidiuretic–vasopressor hormone and oxytocin, and that the paraventricular nucleus constitutes a hypothalamic centre regulating the production of oxytocin by the posterior lobe.

The investigation is proceeding and will be extended to study the melanophore hormone of the intermediate lobe after bilateral destruction of the paraventricular nuclei.

The investigation has been supported by a grant from the Faculty of Medicine, University of Lund.

Hans Olivecrona

Department of Histology,
University of Lund.
Feb. 4.

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Moonlight and the Pregnancy of Malayan Forest Rats

The author of the earlier communication in *Nature* under this title (J. L. H.)[1] wishes to thank his colleague (W. v. d. B.) for pointing out an error in the test of significance used, and for suggesting more rigorous tests. The object of this joint letter is to correct that error and a similar one in another paper which makes use of the same material[2].

In the first communication, the wrong number of degrees of freedom was used, which caused an unjustified significance. When the χ^2-test is correctly applied, the observations cannot sufficiently support the lunar hypothesis.

Table 2 of the earlier communication showed the total number of litters, classed as 'young' (that is, with embryos of less than median weight) or as 'old' (more than median weight), for each five-day period of the lunar month, found on dissecting forest-trapped rats of the species *Rattus mülleri*, *R. sabanus*, *R. whiteheadi* and *R. r. jalorensis*, over some four years. In Table 1 here the same information is shown for each species separately, and the opportunity has been taken of bringing it up to date by adding data for twenty-seven more litters of those species and for twenty-four litters of a fifth species, *R. rajah*, sens. lat., which have accumulated since the earlier figures were prepared. The total shown at the bottom of the table corresponds to Table 2 of the original communication. It is remarkable that a χ^2-test still does not give a significant result, whereas other tests give low probabilities, as we shall demonstrate now.

Better support for the lunar hypothesis can be found by computing the correlation coefficients between each of the sets of figures for 'young' litters and the five sets for 'old' litters in turn corresponding to periods ten days later (see Table 2). Of the 25 coefficients obtained, 18 are positive and only 6 negative (one is zero). The probability of getting such a deviation from equality is less than 0·02. The 25 coefficients transformed to Fisher's z give a mean value of 0·386 with a standard deviation $= \frac{1}{\sqrt{3}} \times \frac{1}{\sqrt{25}} = 0{\cdot}116$, and a probability of less than 0·001. Clearly, there is a significant positive correlation between the average number of 'young' litters at any part of the lunar month and the average number of 'old' litters ten days later in the month.

One can object that this does not prove the hypothesis, for the pregnancy-rate shows decided fluctuations connected with the very variable rainfall, and we would expect the number of 'young' litters at any one *time* to be correlated with the number of 'old' ones ten days later.

The average number of litters per 5-day period, however, is so small (about 0·6) that the rainfall alone cannot explain the observed correlation.

As a further test, Table 3 shows the correlation coefficients (*a*) between the numbers of 'young' litters, and (*b*) between the numbers of 'old' litters in different species for corresponding parts of the lunar month. If there is a tendency for conceptions to be more frequent at some part of the lunar month, then there should be a positive correlation between these figures. Of the twenty values, twelve are positive, a variation which is not significant. The z transformation gives a mean value of z of 0·301 with a standard deviation of $\frac{1}{\sqrt{3}} \times \frac{1}{\sqrt{20}} = 0{\cdot}129$, and a probability of a litter less than 0·02. Clearly there is a significant positive correlation between the numbers of litters of different species at different parts of the lunar month.

Taken together, the two correlations imply that the five species substantially agree in showing a maximum number of 'young' litters in the early part of the lunar month, and a maximum number of 'old' ones later in the month, and that the agreement is too good to be attributable to chance. That this is likely to be an effect of moonlight, and not, for example, of variation in the abundance of insects, fruit or rain, is suggested by the complete absence of any trace of such a variation in the diurnal squirrels and tree-shrews of the forest, which have a rather similar habit and food-supply to the rats. This is illustrated in Table 4, showing the consolidated information for four

Table 1. Numbers of 'Young' and 'Old' Litters of Forest-trapped Rats of Five Species by 5-day Periods of the Lunar Month for the Whole Period April 1948–August 1952

Lunar date	1–5	6–10	11–15	16–20	21–25	26–30
(*M*) *Rattus mülleri*						
'Old'	3	1	2	0	4	3·5
'Young'	3	0	2	4	1	3·5
(*S*) *R. sabanus*						
'Old'	3	4	3	2	7	7
'Young'	3	8	3	6	2	4
(*W*) *R. whiteheadi*						
'Old'	1·8	5·4	4	4	4	8·8
'Young'	4·2	6·6	7	3	2	5·2
(*J*) *R. r. jalorensis*						
'Old'	4	1	1	3	5	4
'Young'	2	0	7	2	5	2
(*R*) *R. rajah*						
'Old'	1	3	2	1	3	2
'Young'	1	1	4	2	1	3
Total, all species						
'Old'	12·8	14·4	12	10	23	25·3
'Young'	13·2	15·6	23	17	11	17·7

Table 2. Coefficients of Correlation between the Numbers in the 'Young' Groups for Each Species and the Numbers in Each of the 'Old' Groups Ten Days Later

'Old' groups of: / 'Young' groups of:	*M*	*S*	*W*	*J*	*R*
M	0·35	0·57	0·83	−0·31	0·65
S	0·55	−0·11	0·56	0	−0·20
W	−0·32	0·06	−0·08	0·01	0·41
J	0·90	0·29	−0·42	0·61	0·53
R	0·41	0·73	0·28	0·28	0·88

Mean = 0·298

Table 3. Coefficient of Correlation between Corresponding Numbers of 'Young' for Different Species (upper right) and of 'Old' for Different Species (lower left)

'Young' / 'Old'	*M*	*S*	*W*	*J*	*R*	'Young'
M	•	−0·20	−0·28	−0·13	0·51	*M*
S	0·78	•	0·36	−0·07	−0·21	*S*
W	0·16	0·71	•	−0·01	0·75	*W*
J	0·66	0·55	−0·01	•	0·56	*J*
R	0·29	0·29	0·40	−0·13	•	*R*
'Old'	*M*	*S*	*W*	*J*	*R*	'Young' / 'Old'

Mean = 0·281

Table 4. The Same Information as for Table 1, for the same Period, consolidated for the Squirrels *C. notatus*, *nigrovittatus*, *caniceps* and *lowii*, and for the Tree-shrews *Tupaia glis* and *minor*

Lunar date	1–5	6–10	11–15	16–20	21–25	26–30
'Old'	5	10	5	7	7	4
'Young'	7	6	5	7	7	6

ecies of squirrels, *Callosciurus notatus, nigrovittatus, niceps* and *lowii*, and two tree-shrews, *Tupaia glis* nd *minor*, brought up to date.

We conclude with the application of a non-parametric test, the method of *m*-rankings[3]. This test as the advantage that the influence of the rainfall eady discussed is still more reduced, for there is connexion between lunar phase and rainfall, so at eventual influence of the rain is spread over the ole lunar month, which may strengthen the correlaon, but does not enlarge the probability of the -rankings test.

The rows of 'young' litters in Table 1 were shifted o places to the right, the last two figures being aced at the beginning of the row. The result, in endall's notation, was:

$$\chi_r^2 = 17{\cdot}8; \quad W = 0{\cdot}355; \quad n = 6; \quad m = 10.$$

$$(n-1)\frac{W}{1-W} = 4{\cdot}953 \text{ with } \nu_1 = 4{\cdot}8 \text{ and } \nu_2 = 43{\cdot}2$$

degrees of freedom has a probability of 0·002.

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Giant Ovaries of a Blue Whale

THE blue whale (*Balaenoptera musculus*) has the largest ovaries of any mammal. Of the combined weights of ovaries recorded by Mackintosh and Wheeler[1] from non-pregnant mature blue whales, the heaviest is 15 lb. The greatest recorded weight of ovaries from a pregnant female appears to be 35 lb. (H. W. Symons, 1953), but this whale, which was 79 ft. in length, had two corpora lutea of pregnancy associated with a single 8-ft. female fœtus. More usually, the weight of the ovaries of a large pregnant blue whale is between 22 and 24 lb.

During the 1953–54 Antarctic whaling season, an 8-ft. female blue whale was worked up on the floating factory *Balaena*, in lat. 63° 56′ S., long. 86° 12′ E. The ovaries, which were associated with a 14-ft. female fœtus, had a combined weight of 131 lb.—more than three times heavier than any previously recorded. The heavier of the pair, containing a large corpus luteum of pregnancy of mean diameter 20 cm., weighed 73 lb. with dimensions of 76 cm. × 49 cm. × 16 cm.; the other weighed 58 lb. and measured 68 cm. × 50 cm. × 14 cm. (see Fig. 1).

Fig. 1. Giant ovaries with metre rule for comparison. The large body at the front of the left-hand ovary is the corpus luteum of pregnancy

Their great size appears to be due largely to the ovarian architecture being on a grand scale, although an unusual amount of adipose tissue is present. Both ovaries have been frozen and will be described in detail at a later date.

I am indebted to Hector Whaling, Ltd., for laboratory accommodation and other facilities on board F.F. *Balaena*.

R. M. LAWS

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Jan. 25.

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Inshore Surface Currents on the West Coast of the Union of South Africa

IN the course of research into the environment of the South African pilchard *Sardinops ocellata* Pappe, and the maasbanker or horse mackerel *Trachurus trachurus* Linnaeus, the importance of a knowledge of the surface currents near the commercial fisheries of these fishes off the west coast of South Africa was quickly shown. These two fishes are found in very large shoals quite close to the west coast. Their commercial importance may be gauged from the fact that in the season January–September 1953 some 151,000 tons of pilchards and 93,000 tons of maasbankers worth *c.* £5 million in finished products (meal, oil and canned fish) were caught in this area.

The eggs and larvæ of these fishes being planktonic are carried away from the spawning areas by surface currents. The main current off the west coast is the Benguela current, which usually has northerly and westerly components. This current tends to remove floating organisms such as fish eggs and larvæ away from the coast, and yet at certain times of the year these, as well as juvenile fish, abound in the small bays such as St. Helena Bay and Lamberts Bay, and later literally millions of adult fish, 3–5 years in age, are caught commercially off the west coast.

Another striking fact is that the *phyllosoma* stage of the rock lobster *Jasus lalandii* Milne Edwards has been found 950 miles west of Saldanha Bay. Again, this is a planktonic organism which tends to be carried away from the coast in surface currents, and yet adult rock lobsters are found in large concentrations all round the west coast, forming the basis of a very valuable export trade for the Union of South Africa.

The problem which arises is the means by which fish and invertebrate populations maintain their concentrations along the west coast in the face of apparently adverse water movements. One solution would be the presence of inshore-setting currents, which would tend to keep a proportion of the eggs and larvæ close to the coast.

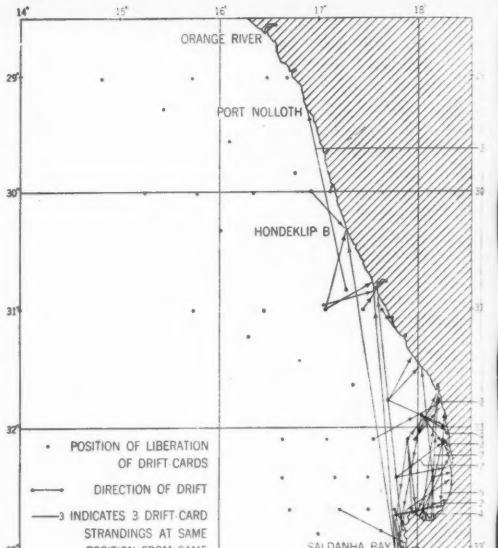
Records of wrecks and strandings along the west coast suggest that on occasion inshore-setting currents

must have been responsible for these occurrences. The west coast is notorious among seafaring men for the difficulty in fixing accurately a ship's position in this vicinity. The incidence of fog, overcast sky and unusual refraction make a navigator's task difficult in the absence of installations on land of modern specialized equipment for accurate fixing of positions at sea. However, as time proceeded, the navigating officers of R.S. *Africana II*, the research ship of the South African Division of Fisheries, were able to accumulate evidence, taken under good conditions, for the presence of inshore-setting currents along the west coast.

In order to augment this evidence it was decided to use 'drift-cards' as an experiment to give results which were continuous and which are independent of the adverse conditions attached to ordinary navigational fixes; this method is due to F. C. W. Olson[1]. Cards bearing identifying marks are placed in plastic envelopes and liberated at sea in the hope that a proportion of these will strand and be returned through the co-operation of the general public. These drift-cards, lying flat in the surface of the sea, offer a minimum resistance to the wind. The plastic chosen was a polyethylene one, sold under the trade name 'Alkathene', and was supplied in 5-in. wide, flat rolls of 500-ft. length from which lengths of 5 in. were cut off. A numbered card was inserted which requested the finder to return the card to the Division of Fisheries after completing details of date and position of finding. The cut edges of the plastic envelope were then sealed by heat and in this manner a waterproof envelope was produced. Ten of these cards were then liberated at each station occupied. The envelopes stream away from the ship and float passively in the sea surface. On occasion, sea-birds such as the wandering albatross, *Diomedea exulans*, take more than a casual interest in them, for sometimes these birds peck at the envelopes and even pick them up in their bills and shake and crumple them. Some envelopes have no doubt been rendered non-watertight in this manner and the cards destroyed in consequence.

The experiment has now been in operation for a year, and out of 4,040 cards liberated at positions up to one hundred miles seaward from the west coast, some 102, a little more than 2½ per cent, have been found on west coast beaches. Bearing in mind the sparsely populated nature of this coast, a return of more than 2½ per cent is not discouraging. Some cards may travel northwards and even pass into the South Equatorial Current and be carried westwards across the South Atlantic Ocean to South America. Recently, a report reached the Division of Fisheries in South Africa that a bottle thrown overboard from R.S. *Africana II* when 450 miles west of Saldanha Bay in June 1951 was cast ashore at the mouth of the Rio Gurupi in Brazil in August 1953. This confirms an earlier stranding in South America of a bottle liberated 26½ miles west of Cape Point and found about a year later on the coast at Pernambuco[2].

One disadvantage of this method of showing movements of currents is that the course taken by the drift card is uncertain, and therefore the distance between the points of liberation and finding is a minimum distance travelled. Also the time interval between liberation and finding is a maximum and therefore speeds of currents worked out from data such as have been described are minimum speeds.



In the recent South African experiment it was found that no card liberated more than 46 miles offshore has been returned from the west coast, the majority of returns being from those set free within 25 miles of the coast. The greatest distance in a direct line between the points of liberation and recovery is 164 miles, this card being found 57 days after being set free. This works out at a minimum speed of nearly three miles a day. The highest minimum speed so far recorded is *c.* ¼ knot. The proportion of cards found north of their point of release to those found to the south is approximately 4–5, the number found to the south being greatly increased during periods of northerly winds in winter.

The accompanying map shows the positions of the strandings of the cards on the west coast, the points from which they were liberated and an indication of the direction in which they travelled. The diagram clearly shows the existence of a number of inshore-setting currents which must have an important effect on the return close to the coast of eggs and larvæ. At present the data are too few to work out seasonal fluctuations in strandings; but later it is hoped to correlate meteorological data with the occurrence of stranding.

A. J. Clowes

Division of Fisheries,
Sea Point,
Cape Town.
Dec. 14.

[1] Olson, F. C. W., *J. Mar. Res.*, **10**, No. 2. 190 (1951).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, May 25

PHYSICAL SOCIETY (in the Lecture Theatre of the Royal Institution, Albemarle Street, London, W.1), at 4.30 p.m.—Annual General Meeting. Prof. R. Whiddington: "Physics in the University and the Nation" (Presidential Address).

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Major-General Sir Leonard Rogers, K.C.S.I., F.R.S.: "Progress Towards the Eradication of Leprosy from the British Commonwealth".

INSTITUTION OF ELECTRICAL ENGINEERS (joint meeting with the Institution of Civil Engineers, at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. C. R. Westlake, Mr. T. A. L. Paton, and Mr. R. W. Mountain: "The Owen Falls, Uganda Hydro-electric Development—General Aspects".

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.30 p.m.—Air Marshal Sir Harold Whittingham: "Medical Science and Problems of Flying". (Further Lecture on May 27.)*

PRESENTATION OF TECHNICAL INFORMATION DISCUSSION GROUP (in the Mechanical Lecture Theatre, University College, Gower Street, London, W.C.1), at 6 p.m.—Mr. F. Greenaway: "Some Historical Aspects of the Presentation of Scientific Information".

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 8.15 p.m.—Prof. W. B. Emery: "Recent Work in Archæology outside Europe". (3) "Egypt".*

Wednesday, May 26

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Mr. W. N. Sproson: "Subjective White in Colour Television"; Dr. M. Gilbert: "Colour Preferences in Television Pictures".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Lord Simon of Wythenshawe, LL.D.: "Some Aspects of World Population and Food Resources".*

Thursday, May 27

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Howard Florey, F.R.S.: "Mucins and the Protection of the Body" (Croonian Lecture).

INSTITUTE OF METALS (at 4 Grosvenor Gardens, London, S.W.1), at 5.30 p.m.—Dr. W. Boas: "Lattice Defects and Energy Stores in Deformed Metals".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. M. Stock and Mr. J. C. Lithgow: "Development and Utilization of Hydro-electric Power in Uganda".

UNIVERSITY COLLEGE LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. H. Clark (University of Wisconsin): "Three Centuries and an Island—a Study in the Historical Geography of Canada". (Further Lectures on May 28 and 31.)*

Friday, May 28

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. J. H. Quastel, F.R.S.: "Soil Metabolism" (The Leeuwenhoek Lecture). (Deferred from Thursday, May 6.)

UNIVERSITY OF LONDON (at Guy's Hospital Medical School, St. Thomas Street, London, S.E.1), at 5 p.m.—Prof. G. Stead: "Making Sound Visible" (Fison Memorial Lecture).

SOCIETY FOR ANALYTICAL CHEMISTRY, PHYSICAL METHODS GROUP (joint meeting with the LIVERPOOL AND NORTH-WESTERN SECTION of the ROYAL INSTITUTE OF CHEMISTRY, at the Harris Institute, Corporation Street, Preston), at 7.30 p.m.—Mr. J. P. Dowdall and Mr. H. Stretch: "A Twin Beam Null Point Fluorimeter"; Mr. G. N. Walton: "Quenching Effects in the Fluorimetric Determination of Uranium".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. D. M. S. Watson, F.R.S.: "Coelacanths".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, King's College, Strand, London, W.C.2 (May 28).

PROFESSOR OF PATHOLOGY at the Royal Medical College, Baghdad—The Secretary, Ministry of Health (Division 5A), Savile Row, London, W.1 (May 28).

VISITING PROFESSOR OF BIOCHEMISTRY at Ankara University, Turkey—The Director, Personnel Department, The British Council, 65 Davies Street, London, W.1, quoting "Biochemistry, Ankara" (May 28).

ASSISTANT EXPERIMENTAL OFFICER (with at least H.S.C. (science) or equivalent, and experience in emission spectroscopy or in electronics), for research and development work in emission spectroscopy—The Establishment Officer, Atomic Energy Research Establishment, Harwell (May 29).

ASSISTANT, Grade B (with a good honours degree in one of the biological subjects) IN THE DEPARTMENT OF PHARMACY AND BIOLOGY, to teach to degree standard; and an ASSISTANT, Grade B (graduate or equivalent qualifications in microbiology, biochemistry, nutrition and food analysis), IN THE DEPARTMENT OF BAKERY AND CATERING, to teach microbiology, nutrition and food analysis—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (May 29).

ASSISTANT (graduate or equivalent qualifications), at the College of Commerce and Technology, Sheffield, to teach physics in national certificate (chemistry and metallurgy) and various City and Guilds Courses—The Director of Education, Leopold Street, Sheffield (May 29).

PHYSICIST TECHNICIAN (with good laboratory workshop experience, and preferably with a practical knowledge of electronics) in the Radiotherapy Institute—The Medical Superintendent, Western General Hospital, Edinburgh 4 (May 29).

READER IN RADIOCHEMISTRY, tenable in the Durham Division of the University—The Registrar, University Office, 46 North Bailey, Durham (May 29).

SENIOR ASSISTANT ENGINEER (Cooling Towers), (preferably with an honours degree in engineering, and a sound knowledge of the fundamentals of the cooling process, proven capacity for original thought, and experience either in the design office of a manufacturer of cooling towers or of economic studies in relation to the design of central power stations) at the British Electricity Authority Headquarters, London, for duties which consist of general investigations into the technical and economic aspects of cooling tower design, together with the preparation of specifications and critical assessments of the technical features and performance of specific designs—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting T/437 (May 31).

LECTURERS (2) (one with qualifications in agricultural zoology, and the other with qualifications in agricultural botany, preferably with some knowledge of bacteriology) IN THE BIOLOGY DEPARTMENT—The Principal, Seale-Hayne Agricultural College, Newton Abbot, Devon (June 1).

ASSISTANT IN CHEMISTRY—The Secretary, The University, Aberdeen (June 4).

LECTURER (graduate in agriculture or pure science, and some research or teaching experience, and considerable experience of farm management) IN AGRICULTURE AND SUPERVISOR OF UNIVERSITY FARMS—The Secretary, The University, Aberdeen (June 4).

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Sheffield (June 5).

ASSISTANT LECTURER (with an honours degree in geology, and preferably some research experience in palaeontology or stratigraphy) IN GEOLOGY—The Secretary, University College London, Gower Street, London, W.C.1 (June 5).

EXPERIMENTAL OFFICERS (with at least H.S.C. (science) or equivalent) IN THE GUIDED WEAPONS DIVISION, Royal Aircraft Establishment, Farnborough, for work concerned chiefly with design, development and performance of new weapons and associated guidance and control systems; instrumentation of flight trials and investigation of trials results—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.296/54A. (June 5).

RESEARCH ASSISTANT AND DEMONSTRATOR (preferably with a knowledge of cytogenetics) IN THE DEPARTMENT OF BOTANY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (June 5).

PHYSICIST or ENGINEER (with first- or second-class honours degree or equivalent in physics or engineering, and preferably with a working knowledge of electronics and servo-techniques) IN THE INSTRUMENT AND PHOTOGRAPHIC DEPARTMENT, Royal Aircraft Establishment, Farnborough, to work on development of new automatic pilots and adaptation of existing equipment for special purposes, which will involve designing of electromechanical instrument devices, supervision of associated experimental work, and considerable contact with industry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.272/54A. (June 11).

GUINNESS RESEARCH FELLOW (graduate with experience in research) IN MICROBIOLOGICAL BIOCHEMISTRY—The Whitley Professor, Department of Biochemistry, The University, South Parks Road, Oxford (June 12).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, The University, Leeds 2 (June 21).

LECTURER IN THE DEPARTMENT OF VETERINARY PHYSIOLOGY, Royal (Dick) School of Veterinary Studies—The Secretary, The University, Edinburgh (June 30).

NORTH THAMES GAS BOARD FELLOWSHIP IN GASEOUS FUELS AND COMBUSTION, tenable at Imperial College—The Registrar, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7 (July 1).

ASSISTANT LECTURER (with an honours degree in psychology or equivalent) IN PSYCHOLOGY, with special reference to general and experimental psychology—The Secretary, University College London, Gower Street, London, W.C.1 (July 3).

AGRONOMIST (with at least a second-class honours degree, and not less than two years appropriate postgraduate experience, preferably including acquaintance with tropical tree crops and up-to-date knowlege of the statistical analysis of field experimental results) at the West African Cocoa Research Institute, Gold Coast, to assist in laying down field experiments on various methods of cultivating cocoa—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting 27059/130.

ASSISTANT BIOCHEMIST (with an honours degree, and preferably with experience in electrophoresis and spectrographic techniques)—The Director, Cancer Research Department, Royal Beatson Memorial Hospital, 132–138 Hill Street, Glasgow, C.3.

ASSISTANT IN EXPERIMENTAL PHARMACOLOGY—The Secretary of University Court, The University, Glasgow.

ASSISTANT LECTURER, Grade B (with a good honours degree in zoology, with subsidiary botany, and preferably with an interest in embryology and/or cytology), IN ZOOLOGY—The Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent.

ASSISTANT STATISTICIAN (with a degree in mathematics or economics, and preferably with an interest in the use of punched-card work and electronic computing equipment) IN THE DEPARTMENT OF STATISTICS, to carry out the more advanced type of statistical computations, and supervise routine statistical work of the computing staff of the Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

BIOCHEMIST (preferably with experience of recent methods used in general medical clinical biochemistry)—The Medical Superintendent, Morriston Hospital, Swansea.

ELECTRICAL ENGINEERS and PHYSICISTS (with at least H.S.C. (science) or equivalent) at the Ministry of Supply Radar Research Establishment, Malvern, Worcs., for research and development work on radio and electronic equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.121/54A.

LECTURER (preferably with industrial, teaching and research experience) IN TECHNICAL CHEMISTRY—The Secretary, Royal Technical College, Glasgow.

LECTURER (with qualifications in physical chemistry) IN CHEMISTRY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

METALLURGISTS, ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER grades (with at least H.S.C. (science) or equivalent (Ref. F.29/54A); SCIENTIFIC OFFICER grade (with first- or second-class honours degree in metallurgy, or in physics or chemistry with bias to metallurgy) (Ref. F.30/54A), at Experimental Establishments in the South of England, for research and development work chiefly on corrosion, fatigue, high temperature materials and light alloy technology—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No.

OFFICER (with at least H.S.C. in science subjects, and experience in technical journalism, and preferably with technical knowledge in the field of atomic energy) in the Department of Atomic Energy Industrial Group Headquarters, to undertake scientific and technical editorial work covering the entire field of the Industrial Group's activities; the preparation of briefs and drafts on general as well as specified fields, particularly for publication and lectures; liaison with Press Office on publicity; and arranging visits of outside bodies to the Group's Headquarters and factories—The Department of Atomic Energy, Industrial Group Headquarters, Risley, Warrington, quoting 589.

TECHNICIAN (preferably with a knowledge of glassblowing and vacuum techniques) IN THE DEPARTMENT OF PHYSICS, to assist particularly with research work—The Secretary and Registrar, The University, Southampton.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Fingerprint Facts: a Reminiscent Monograph. By George Wilton Wilton. Pp. vi+20+5 plates. (Galashiels: A. Walker and Son, Ltd., 1953.) [173

Security and Responsibility. By Prof. Kathleen Lonsdale, F.R.S. (Alex Wood Memorial Lecture, 1954.) Pp. 32. (London: Fellowship of Reconciliation, 1954.) 1*s*. 6*d*. [173

Pacifism: a Personal Challenge. By Howard Diamond. Pp. 8. (London: Fellowship of Reconciliation, 1954.) 6*d*. [173

The Complete Spraying Programme, 1954, for Fruit Growers, Market Gardeners and Farmers. Pp. 96. (Wheathampstead: The Murphy Chemical Company, Ltd., 1954.) [173

Murex Limited. Review, Vol. 1, No. 13: The Significance of Hydrogen in Steel Manufacture. By K. C. Barraclough. Pp. 305–352. (Rainham, Essex: Murex, Ltd., 1954.) [173

Year Book of the Textile Institute. No. 6: 1953–54. Pp. xviii+60+166. (Manchester: The Textile Institute, 1954.) 15*s*. [173

Department of Scientific and Industrial Research. (Joint Fire Research Organization.) National Building Studies. Special Report No. 22: Fire Hazard of Internal Linings. By D. Hird and C. F. Fischl. Pp. iv+12+4 plates. (London: H.M. Stationery Office, 1954.) 1*s*. 3*d*. net. [173

Royal Astronomical Society. Occasional Notes. Vol. 15, No. 3 (October 1953): Heights and Names of Mount Everest and Other Peaks. By J. de Graaff-Hunter. The Construction of the Earth to a Depth of 750 kilometers. By Ernest Tillotson. Pp. 28+4 plates. 3*s*. Title Page and Index to Vol. 2 (Nos. 10–14). (London: Royal Astronomical Society, 1953.) [173

Institution of the Rubber Industry. Annual Report on the Progress of Rubber Technology. Vol. 17, 1953. Pp. xii+174. (Cambridge: Heffer and Sons, Ltd., 1954.) 21*s*. [173

Air Ministry: Meteorological Office. Geophysical Memoirs No. 92 (Seventh Number, Vol. XI): Day-to-Day Variations in the Tropopause. By J. S. Sawyer. (M.O. 530g.) Pp. 40. (London: H.M. Stationery Office, 1954.) 5*s*. net. [173

Imperial Forestry Institute, University of Oxford. Twenty-Ninth Annual Report, 1952–53. Pp. 30. (Oxford: Holywell Press, Ltd., 1954.) [173

University of Leeds. Annual Report of the Librarian. Session, 1952–53. Pp. 12. (Leeds: The University, 1953.) [173

British Plastics Federation. Annual Report of the Chairman and Council for 1953. Pp. 20. (London: British Plastics Federation, 1954.) [173

Proceedings of the Society for the Study of Fertility. No. 5: Liverpool Conference, 1953. Pp. iii+105+15 plates. (Cambridge: W. Heffer and Sons, Ltd., 1954.) [173

Bulletin of the British Museum (Natural History). Geology. Vol. 2, No. 4: Some Upper Cretaceous and Eocene Fruits from Egypt. By Marjorie E. J. Chandler, with Appendices by M. Y. Hassan and M. I. Youssef. Pp. 147–187+plates 10–16. 16*s*. Entomology. Vol. 3, No. 6: The Early Literature on Mallophaga. Part 3: 1776–1786. By Theresa Clay and G. H. E. Hopkins. Pp. 221–266+plates 10–12. 10*s*. (London: British Museum (Natural History), 1954.) [173

British Museum (Natural History). Fossil Mammals of Africa. No. 7: The Miocene Hyracoids of East Africa, with some observations on the order Hyracoidea. By T. Whitworth. Pp. iii+58+7 plates. (London: British Museum (Natural History), 1954.) 25*s*. [173

Colonial Office. An Economic Survey of the Colonial Territories, 1951. Vol. 2: The East African Territories—Kenya, Tanganyika, Uganda, Zanzibar and the Somaliland Protectorate, with Aden, Mauritius and Seychelles. (Colonial No. 281–2.) Pp. 204. (London: H.M. Stationery Office, 1954.) 32*s*. 6*d*. net. [173

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Research Film. No. 1 (November 1952). Pp. 28. (Bulletin of the Research Film Committee of the International Scientific Film Association.) (Göttingen: Institut für Film und Bild, 1952.) [173

Sveriges Geologiska Undersökning. Ser. C, No. 508: Interpretation of Magnetic Anomalies at Sheet-Like Bodies. By S. Werner. Pp. 130+xxii. 8 kronor. Årsberätt för År 1949. Pp. 8. 0.50 kronor. (Stockholm: Kungl. Boktryckeriet. P. A. Norstedt and Söner, 1953.) [173

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Notas de Física No. 13: The Anomalous Large Angle Scattering of $m\mu$ Mesons. By J. P. Davidson. Pp. 3. (Rio de Janeiro: Centro Brasileiro de Pesquisas Físicas, 1953.) [173

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